A lighting unit 100 and a luminaire are provided. The lighting unit 100 is for illumination and for purifying air and comprises an air inlet 18, an air outlet 112, a solid state light emitter 122, a photocatalytic volume 116 and a light exit window 104. The air inlet 118 receives an air flow 120. The solid state light emitter 122 emits light 124 in a first spectral range. The solid state light emitter 122 is arranged between the air inlet 118 and the air outlet 112 such that, in use, a portion of the air flow 120 flows along the solid state light emitter 122. The photocatalytic volume 116 comprises multiple elongated structures 108 with a photocatalytic material on a surface of the elongated structures 108. The photocatalytic volume 116 allows the air flow to flow through the photocatalytic volume 116. The photocatalytic volume 116 is arranged between the air inlet 118 and the air outlet 112 such that, in use, a portion of the air flow flows through the photocatalytic volume 116, and the photocatalytic volume 116 is arranged to receive light 124 which is emitted by the solid state light emitter 122. The photocatalytic material is a catalyst in photoreactions between gasses in the air flow 120 under the influence of light being comprised in the first spectral range. The light exit window 104 transmits visible light into an ambient of the lighting unit 100.

Fig. 1
A lighting unit and a luminaire for illumination and for purifying air

FIELD OF THE INVENTION

The invention relates to lighting units which are also used as air purifiers. The invention further relates to luminaires comprising an air purifying lighting unit.

BACKGROUND OF THE INVENTION

Published patent application US2013/0211332 discloses a reflector element for an electric lamp. The reflector element may comprise on its surface a photocatalytic material (such as, for example, TiO₂) and/or a phosphor material. The reflector element may be used in combination with a lamp which illuminates the photocatalytic material with light of a specific wavelength, for example, UV light to enable the photocatalytic material to purify air. The lamp also illuminates the phosphor material which converts impinging light towards light of another color to lighten a room. The lamp may emit ultraviolet light and the lamp may comprise Light Emitting Diodes. A combination of the lamp and the reflector of the cited patent application purifies air and illuminates the environment. The combination of the lamp and the reflector used hitherto has two typical disadvantages. A first one is that, especially when Light Emitting Diodes are used, the amount of emitted light is limited by the amount of heat which the Light Emitting Diodes produce on a relatively small area. This leads to a relatively small amount of light being available for illuminating the environment and illuminating the photocatalytic material. Another problem is that the amount of photocatalytic material which is in contact with air is relatively small and, thus, the amount of air which may be purified per time unit is limited.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a lighting unit which is capable of purifying more air per time unit while maintaining a relatively large output of visible light.

A first aspect of the invention provides a lighting unit. A second aspect of the invention provides a luminaire. Advantageous embodiments are defined in the dependent claims.
A lighting unit for illumination and for purifying air in accordance with the first aspect of the invention comprises an air inlet, an air outlet, a solid state light emitter, a photocatalytic volume and a light exit window. The air inlet receives an air flow. The solid state light emitter emits light in a first spectral range. The solid state light emitter is arranged between the air inlet and the air outlet such that, in use, at least a portion of the air flow flows along the solid state light emitter. The photocatalytic volume comprises multiple elongated structures with a photocatalytic material on a surface of the elongated structures. The photocatalytic volume allows the air flow to flow through the photocatalytic volume. The photocatalytic volume is arranged between the air inlet and the air outlet such that, in use, at least a portion of the air flow flows through the photocatalytic volume, and the photocatalytic volume is arranged to receive light which is emitted by the solid state light emitter. The photocatalytic material is a catalyst in photoreactions between gasses in the air flow under the influence of light being comprised in the first spectral range. The light exit window transmits visible light into an ambient of the lighting unit.

The multiple elongated structures of the photocatalytic volume contribute to the fact that the photocatalytic volume has, compared to its volume, a relatively large surface area. Consequently, a relatively large amount of photocatalytic material may be exposed to air which flows through the photocatalytic volume. The relatively large amount of photocatalytic material is only capable of assisting in reactions between a relatively large amount of hazardous or unpleasant gasses in the air flow if enough light impinges on the material. Traditionally it was difficult to get a large enough light flux into the photocatalytic volume with traditional lamps such as discharge tubes - it was especially difficult if the lighting unit has to be relatively compact. Solid state light emitters have proven to be a very good, relatively small, source of high intensity light. However, solid state light emitters become relatively hot and the amount of used solid state light emitters is often limited by options for cooling them. In the current invention, the solid state light emitter is arranged in the air flow and the air flow cools the solid state light emitter such that the temperature of the solid state light emitter is reduced. Thus, a high power solid state light emitter may be used without having the risk of an overheated solid state light emitter. Consequently, enough light impinges on the relatively large amount photocatalytic material and a relatively large amount of air may be purified.

Hence, in the current invention the air there is a synergistic effect between the fact that the photocatalytic volume comprises a relatively large amount of photocatalytic material and the fact that the fact that the solid state light emitter is arranged within the air.
flow. If more photocatalytic material is present, more air may be purified. If more air may be purified, the air flow may transport more air per time unit. If the air flow transports more air per time unit, the solid state light emitter is better cooled, and, consequently, the solid state light emitter may emit more light. If more light is emitted, more air may be purified and/or more photocatalytic material can be used in an effective way and more photocatalytic material may be provided on the surface of the elongated structures of the photocatalytic volume. Subsequently, more air may be purified, etc. Thus, the possibility to use a relatively large amount of photocatalytic material on the surface of the elongated structures of the photocatalytic volume and the placement of the solid state light emitter in the air flow together contribute to the purification of more air per time unit by the lighting unit.

The solid state light emitter and the photocatalytic volume are arranged in between the air inlet and the air outlet. In between does not necessary mean that, when a straight line is drawn from the air inlet to the air outlet, the line crosses the solid state light emitter and the photocatalytic volume, but it means that at least a portion of the air flow is able to flow along the solid state light emitter and through the photocatalytic volume. Between the air inlet and the air outlet an air flow path, or several air flow paths, are present and the air that flows along the air flow path at least passes the solid state light emitter and/or the photocatalytic material of the photocatalytic volume.

The light of the first spectral range as emitted by the solid state light emitter may comprise light in the visible spectral range and/or in the non-visible spectral range. The photocatalytic material is at least sensitive for a sub-range of the first spectral range. Thus, in order to purify air, the photocatalytic material has to receive, in operation, light of this sub-range. Thus, the photocatalytic material may be reactive to visible or invisible electromagnetic radiation. Visible light is light which may be seen by the naked human eye. Thus, the visible spectral range starts at about 380 nanometers (violet) and ends at about 750 nanometers (deep red light).

The lighting unit comprises a light exit window through which visible light is transmitted into the ambient. If the solid state light emitter only emits light in the non-visible spectral range, the lighting unit may comprises a light conversion element for converting some light in the invisible spectral range towards light in the visible spectral range. If the solid state light emitter emits at least some light in the visible spectral range, at least a portion of this visible light is emitted through the light exit window into the ambient of the lighting unit.
The photocatalytic volume comprises multiple elongated structures. It means that the photocatalytic volume comprises a multitude of elongated structures. In an embodiment, the photocatalytic volume comprises more than 100 elongated structures. In another embodiment, the photocatalytic volume comprises more than 1000 elongated structures. In further embodiment, the photocatalytic volume comprises more than 10000 elongated structures. Elongated structures are structures which are relatively long compared to their thickness. Examples are bars, rid, wires, fibers, etc. The elongated structures are not necessary straight - they may be bended, curved and/or folded. The elongated structures may be connected to each other, for example with a glue, or by means of soldering, and they may also be detachable. If they are detachable, their interrelated structure keeps them together such that the elongated structures for a volume. Because it must be possible to transport air through the photocatalytic volume, there are open spaces between the elongated structures which extend from a first position at a surface of the photocatalytic volume towards a second different position at the surface of the photocatalytic volume, preferably, from a first side to a second opposite side of the photocatalytic volume. The surface of the photocatalytic volume is an imaginary surface which is formed by an envelope around the multiple elongated structures. Thus, the borders of the photocatalytic volume are defined by this envelope.

The term photocatalytic material is a well-known term for persons skilled in the art of, for example, air purification. These materials are a catalyst which accelerate a reaction by absorbing light. In the context of air purification and, thus, in the context of this invention, they assist, under influence of light of specific wavelengths, in reactions between gasses in the air flow such that hazardous or unpleasant gasses in the air flow are eliminated. The photocatalytic materials only operate as a good catalyst when they receive light of the specific wavelengths. In the context of the invention these specific wavelengths are present in the first spectral range. A well-known examples of photocatalytic materials which may be used to purify air is, for example, TiO$_2$. In this application other suitable photocatalytic materials are discussed.

Examples of solid state light emitters are Light Emitting Diodes (LEDs), Organic Light Emitting diode(s) OLEDs, or, for example, laser diodes. In some embodiments the solid state light source may be a blue light emitting LED, such as InGaN based LED, for example, emitting primary light of the wavelength range from 440 to 460 nm. Alternatively, the solid state light source may emit UV or violet light which is subsequently converted into light of longer wavelength(s) by one or more luminescent materials.
Optionally, the lighting unit further comprises a luminescent layer which comprises luminescent material. The luminescent material being arranged to absorb a portion of the light of the first spectral range and to convert a portion of the absorbed light into light of a second spectral range. The luminescent layer is arranged to receive light emitted by the solid state light emitter and to emit the light of the second spectral range at least partially towards the light exit window. The second spectral range is different from the first color spectrum and at least comprises light in the visible spectral range. Thus, the luminescent material may be used to tune the color of the light that is being emitted through the light exit window. For example, when the solid state light emitter emits blue light, the luminescent material may be used to convert some blue light towards yellow light such that the combined light emission through the light exit window is substantially white light (light having a color point in a color space close to or on the black body line). It further allows the selection of a solid state light emitter which emits light in an optimal first spectral range with respect to the operation of the photocatalytic material such that as much as possible air is purified by the lighting unit because the luminescent layer may be used to generate light in the second spectral range such that the light emission through the light exit window has the required color distribution. The luminescent layer may be partially light reflective such that a portion of the light which impinges on the layer is reflected and, in another optional embodiment, the luminescent layer is light transmitting such that a portion of the light which impinges on the layer is at least partially transmitted through the layer.

Optionally, the luminescent material comprise at least a luminescent material selected from the group of inorganic phosphors, organic phosphors and particles showing quantum confinement and having at least in one dimension a size in the nanometer range.

The luminescent layer may also comprise a further luminescent material selected from one of the above groups. The luminescent material and the further luminescent material may be provided as a mix in a single layer, or they may be spatially separated within a single layer. The lighting unit may further comprise a further luminescent layer which comprises another luminescent material which is selected from one of the above groups. The luminescent layer and the further luminescent layer may be provided as a stack of layers on top of each other or they may be arranged at different positions within the lighting unit.

The inorganic luminescent material may comprises a yellow emitting in organic phosphor, such as, for example, YAG (Y₃Al₅O₁₂:Ce) and/or LuAG (Lu₃Al₅O₁₂), or a red inorganic phosphor such as ECAS ((Eu,Ca)SiAlN₃) and/or BSSN ((Ba,Sr)₂Si₅N₈:Eu).
Organic phosphors have a high quantum efficiency and are often transparent, which prevents undesired scattering and increases efficiency. Organic luminescent materials have more advantages. The position and the bandwidth of the luminescence spectrum can be designed with ease to be anywhere in the visible range. As such it is relatively easy to manufacture a light source which emits white light with high efficacy. The white light may be a combination of at least two colors of light, and, thus, the light source may comprise a single light emitter which emits light of a first color and comprise at least one organic luminescent material which converts a part of the light of the first color into a light of a second color. The organic phosphor may be a material which comprises a perylene derivative, such as a yellow emitting perylene derivative, or a red/orange emitting perylene derivate. Such perylene derivatives are commercially available under the name Lumogen Yellow F083 or F170, Lumogen Red F305 and Lumogen Orange F240.

Particles showing quantum confinement and having at least in one dimension a size in the nanometer range are, for example, quantum dots, quantum rods or quantum tetrapods. Having a size in one dimension in the nanometer range means that, for example, if the particles are substantially spherical, their diameter is in the nanometer range. Or, this means that, for example, if they are wire-shaped, a size of a cross-section of the wire is in one direction in the nanometer range. A size in the nanometer range means that their size is at least smaller than 1 micrometer (e.g. smaller than 500 nanometer) and larger or equal to 0.5 nanometer. In an embodiment, the size in one dimension is smaller than 50 nanometer. In another embodiment the size in one dimension is in the range from 2 to 30 nanometer.

Quantum dots are small crystals of semiconducting material generally having a width or diameter of only a few nanometers. When excited by incident light, a quantum dot emits light of a color determined by the size and material of the crystal. Light of a particular color can, therefore, be produced by adapting the size of the dots.

Optionally, a gap is present between the luminescent layer and the solid state light emitter and the luminescent layer and the solid state light emitter are arranged such that, in use, a portion of the air flow flows through the gap. When a gap is present between the luminescent layer and the solid state light emitter, one speaks about a luminescent layer in a remote or a vicinity configuration. In such a configuration the luminescent layer does not directly receive heat from the solid state light emitter (as the result of contact between the luminescent layer and the solid state light emitter) such that the luminescent layer remains efficient and is not fast deteriorated or destroyed. Heat is one of the main causes of a drop in efficiency of luminescent materials and heat may decrease the life time of the luminescent
layer. The luminescent layer itself does also become warm because of the generation of heat in the luminescent material when light from the first spectral range is converted into light of a second spectral range. The air flow is also used to cool the luminescent layer thereby preventing overheating of the luminescent layer. Thus, if the solid state light emitter emits a relatively high amount of light and the luminescent material has to convert a relatively large amount of light, the risk of overheating of the luminescent material is prevented.

Optionally, the photocatalytic volume is configured to be at least partially light transmitting and is arranged to transmit light emitted by the solid state before the emitted light is transmitted through reaches the light exit window into the ambient or, when a luminescent layer is present, before the emitted light impinges on the luminescent material. Thus, the emitted light is transmitted through the photocatalytic volume and, thus, most of the photocatalytic material being present in the photocatalytic volume receives light such that it can assist in photoreactions between gasses in the air flow. Furthermore, because of the elongated structures and the photocatalytic material, the photocatalytic volume is not transparent, but the photocatalytic volume will locally reflect and scatter the transmitted light which results in a relatively homogenous light intensity output at one of the surfaces of the photocatalytic volume.

Optionally, the photocatalytic volume is at least partially light reflective and is arranged to reflect light emitted by the solid state light emitter before the emitted light is transmitted through the light exit window into the ambient, or, when the luminescent layer is present, before the emitted light impinges on the luminescent material. If the photocatalytic volume is arranged in a so-termed reflective-arrangement, still a lot of the light emitted by the solid state light emitter may penetrate the photocatalytic volume to activate the photocatalytic material, and the photocatalytic volume may assist in the spreading of light into a plurality of different light emission directions - the elongated structures and the photocatalytic material at least partially diffusely reflects and scatters impinging light. Consequently, the light output through the light exit window is has a relatively homogeneous light intensity.

Optionally, the first spectral range comprises light in the visible spectral range. In other words, the first spectral range and the visible spectral range overlap at least in a portion of the first spectral range.

Optionally, the first spectral range comprises blue light and/or comprises light in the Ultra Violet spectral range. Particular photocatalytic materials, such as TiO₂ assist the
photoreactions between gasses in the air flow when they receive UV light. Other photocatalytic materials assist in the photoreactions when they receive blue light.

Optionally, the photocatalytic material comprises TiO$_2$. TiO$_2$ may also comprises C or N in its crystal structure such that TiO(2)_x:C_x is obtained or TiO(2)_x:N_x. These from pure TiO$_2$ derived materials are a good photocatalyst under the influence of blue light. Other example of suitable materials are: SrTiO$_3$, Na$_2$Ti$_6$O$_{13}$, BaTi$_4$O$_{13}$. In another optional embodiment, the cross-sectional diameter is smaller than 10 micrometer. The bars or volumes woven Bengal visible LaTaON$_2$, SrTa$_2$, TiO$_2$ doped with transition metal ions to induce absorption in the visible part of the spectrum, such as Fe or Co, TiO$_2$ in a quasi two dimensional structure with a reduced bandgap (see, for example, Nature Chemistry, Volume 3, Issue 4, pp. 296-300 (2011)). Alternatively, materials can be used that generate reactive O$_2$ on irradiation with light, the reactive O$_2$ in turn does the actual purification reaction. Such materials comprise, for example: Indocyanine green, Phthalocyanine, Methylene blue, Sulforhodamine 101, Bengal rose, Tetraphenylporphyrine, Bacteriachlorophyll a, Coumarin 6, Coumarin 343, Coumarin 314, Coumarin 30, DCV-5T.

Optionally, the elongated structures are fibers. Fibers are relatively thin and, as such, do they have a relatively large surface area on which the photocatalytic material may be applied. Fibers are also flexible, which means that it is relatively easy to manufacture a flexible photocatalytic volume or to manufacture photocatalytic volumes of specific shapes.

Optionally, the photocatalytic volume is a woven or non-woven material made of the fibers. Many manufacturing techniques are well known to manufacture woven or non-woven material and all the techniques provide a lot of flexibility for creating photocatalytic volumes of a specific strength, density, shape, etc. In a specific embodiment, the photocatalytic volume has a felt-like structure. The felt-like structure is made by matting, condensing and pressing the fibers in a specific shape.

Optionally, the fibers are glass fibers, quartz fibers or aluminum or aluminum oxide nano-wires.

Optionally, the elongated structures are bars or wires of aluminum or aluminum oxide which have a cross-sectional diameter which is smaller than 1 millimeter. In an embodiment, the cross-sectional diameter is smaller than 100 micrometer. In another optional embodiment, the cross-sectional diameter is smaller than 10 micrometer. The bars or
wires of aluminum or aluminum oxide may be part of porous aluminum / aluminum oxide. The bars or wires may be used in a woven structure. The bars or wires are arranged in layers on top of each other and are welded or glued to each other.

Optionally, the lighting unit comprises a plurality of solid state light emitters for emitting light of the first spectral range and wherein the plurality of solid state light emitters are arranged in a LED on wire array. A LED on wire array consists of Light Emitting Diodes (LEDs) which are connected to each other by wires and no supporting layer or a substrate is present which provides support to the LEDs. The support to the LEDs is provided by the wires and the areas between the LEDs and between the wires are open, which means, air may flow between them. LED on wire arrays have the problem of heat management, because it is relatively difficult for the LEDs to transfer their heat to the environment. In the current invention the air flow cools the LEDs and the LED on wire array has additional open spaces through which the air may flow such that a better cooling is obtained. It is to be noted that not necessary all LEDs of the LED on wire array have to emit light of the first spectral range.

Optionally, the lighting unit further comprises a tube of a light transmitting material and a plurality of solid state light emitters which are configured to emit light in the first spectral range. The air inlet is arranged at a first end of the tube. The air outlet is arranged at a second end of the tube and the second end is opposite the first end. The plurality of solid state light emitters is arranged on a TLED strip which is arranged in an axial direction in the tube. The photocatalytic volume has an elongated shape and is arranged in the axial direction in the tube. When a luminescent layer is present, the luminescent layer has an elongated shape and is also arranged in the axial direction in the tube. The lighting unit in the shape of a tube may be used in luminaires which are suitable for traditional discharge tubes. Furthermore, the shape is such that the air flow may be optimally brought in contact with the photocatalytic material (for air purification) and the solid state light emitters (for cooling).

Optionally, the lighting unit further comprises an air flow creator for providing an air flow to the air inlet. An air flow creator is a means which mechanically moves air into a specific direction. The air flow creator may be a fan. It is to be noted that the invention is not limited to lighting units which comprises the air flow creator. In specific embodiments, the air inlet of the lighting unit may be coupled to a system which provides an air flow, such as, for example, an air-conditioning system of a building.

According to the second aspect of the invention, a luminaire is provided which comprises a lighting unit according to the first aspect of the invention.
The luminaire according to the second aspect of the invention provides the same benefits as the lighting system according to the first aspect of the invention and has similar embodiments with similar effects as the corresponding embodiments of the system.

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

It will be appreciated by those skilled in the art that two or more of the above-mentioned options, implementations, and/or aspects of the invention may be combined in any way deemed useful.

Modifications and variations of the lighting units and the luminaire, which correspond to the described modifications and variations of the lighting unit, can be carried out by a person skilled in the art on the basis of the present description.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Fig. 1 schematically shows a cross-sectional view of a lighting unit according to the first aspect of the invention,

Fig. 2 schematically shows a cross-sectional view of another example of a lighting unit,

Figs. 3a and 3b schematically show examples of a photocatalytic volume,

Fig. 4 shows an exploded view of the interior of a lighting unit which comprises LEDs in a LED on wire array arrangement,

Fig. 5a shows a three dimensional view of an exterior of a lighting unit,

Figs. 5b and 5c show cross-sectional views of a lighting unit such as, for example, the lighting unit of Fig. 5a, and

Fig. 6 schematically shows an interior of a room comprising two luminaires according to the second aspect of the invention.

It should be noted that items denoted by the same reference numerals in different Figures have the same structural features and the same functions, or are the same signals. Where the function and/or structure of such an item have been explained, there is no necessity for repeated explanation thereof in the detailed description.

The Figures are purely diagrammatic and not drawn to scale. Particularly for clarity, some dimensions are exaggerated strongly.
DETAILED DESCRIPTION

Fig. 1 schematically shows a cross-sectional view of a lighting unit 100 according to the first aspect of the invention. The lighting unit 100 has a housing 114. The three dimensional shape of the housing 114 is, for example, the shape of a box or of a cylinder. The housing 114 as an air inlet 118 for receiving, in use, an air flow 120. The air flow 120 flows through the lighting unit 100 as indicated by the wide arrows until it can leave the lighting unit through the air outlet 112. The lighting unit 100 comprises a solid state light emitter 122 which emits light 124 in a first spectral range. At one of the surfaces of the housing 114 a light exit window 104 is present which may comprise, such as drawn in the example of Fig. 1, a transparent layer 102 for preventing that air flows through the light exit window 104. In another embodiment, a segment of the housing 114 are made of a transparent material and the segment acts as a light exit window 104. At least visible light 106 is emitted into the ambient of the lighting unit 100 through the light exit window 104. The visible light 106 may be used to illuminate a room or a specific object. If the lighting unit 100 does not comprise any color conversion element or specific surface of a particular color, the visible light 106 emitted through the light exit window 104 may have substantially the same spectral distribution as the light 124 emitted by the solid state light emitter 122.

The lighting unit also comprises a photocatalytic volume 116 which comprises elongated elements 108 on which a photocatalytic material is applied. In the example of Fig. 1, the elongated elements 108 are, for example, glass fibers which are arranged in a felt-like structure. The photocatalytic material is configured to assist in photoreactions between gasses in the airflow 120 under the influence of the reception of light 124 of the first spectral range. The whole first spectral range may activate the photocatalytic material, or specific wavelengths in the first spectral range may activate the photocatalytic material. The photocatalytic volume 116 is at least partially light transmitting such that also some light 124 of the first spectral range is transmitted towards the light exit window 104. Thus, in the arrangement of Fig. 1, the photocatalytic volume 116 is arranged in a so-termed light transmission mode. In one of the following embodiments the photocatalytic volume 116 is arranged in a so-termed light reflective mode. The photocatalytic volume 116 is also air flow transmitting, which means if an air flow impinges on one of the surface of the photocatalytic volume 116, at least some of the air is transmitted through the photocatalytic volume 116 and the air flow leaves the photocatalytic volume 116 at another surface. In specific embodiments, the pressure of the air flow must be above a predetermined pressure to allow the transmission of the air through the photocatalytic volume 116.
The air flow 120 partially flows along the solid state light emitter 122, thereby cooling the solid state light emitter 122. This allows the use of solid state light emitter 122 which emits a relatively large amount of light in the first spectral range. The photocatalytic volume 116 comprises the elongated elements 108 and the photocatalytic material is provided on the surface of the elongated elements 108. The total surface of the elongated element 108 in contact with air is relatively large and as such a relatively large amount of photocatalytic material may be provided on the elongated elements 108. The combination of a relatively high intensity of light and the relatively large amount of photocatalytic material results in a large air purifying capacity. Hence, the lighting unit 100 is capable of purifying a relatively large air flow 120.

Skilled persons in the field of air purification know suitable photocatalytic materials which assist in reactions between gasses in the air flow under the influence of at least some light in the first spectral range. These materials are a catalyst which accelerate a photoreaction. In the context of air purification and, thus, in the context of this invention, they assist, under influence of light of a specific wavelengths, in reactions between gasses in the air flow such that hazardous or unpleasant gasses in the air flow are eliminated. The photocatalytic materials only operate as a good catalyst when they receive light of the specific wavelengths. In the context of the invention these specific wavelengths are present in the first spectral range. Well known examples of photocatalytic materials which may be used to purify air are: TiO\(_2\), SrTiO\(_3\), Na\(_2\)Ti\(_6\)O\(_{13}\), BaTi\(_4\)O\(_3\), K\(_2\)La\(_2\)Ti\(_3\)O\(_{10}\), ZrO\(_2\), K\(_4\)Nb\(_6\)O\(_{17}\), Sr\(_2\)Nb\(_2\)O\(_6\), K\(_3\)Ta\(_3\)Si\(_2\)O\(_{15}\), LiTaO\(_3\), NaTaO\(_3\), KTaO\(_3\), BaTa\(_2\)O\(_6\), CaTa\(_2\)O\(_6\), RbNdTa\(_2\)O\(_7\), SrTa\(_2\)O\(_6\), Sr\(_2\)Ta\(_2\)O\(_7\), RbNbW\(_6\), CsNbWO\(_6\), CsTaWO\(_6\), ZnGa\(_2\)O\(_4\), LiInO\(_2\), NaInO\(_2\), CaIn\(_2\)O\(_4\), SrIn\(_2\)O\(_4\), Zn\(_2\)GeO\(_4\), Sr\(_2\)SnO\(_4\), NaSb\(_2\), CaSb\(_2\), Sr\(_2\)Sb\(_2\), LaTiO\(_3\), CaNb\(_2\)N, TaON, Ta\(_3\)N\(_5\), CaTaO\(_2\), SrTaO\(_2\), BaTaO\(_2\), LaTaO\(_2\), TiON\(_x\), Ti\(_x\)Ta\(_x\), Na\(_2\)F\(_x\), TiO\(_2\) doped with transition metal ions to induce absorption in the visible part of the spectrum, such as Fe or Co, TiO\(_2\) in a quasi two dimensional structure with a reduced bandgap (see, for example, Nature Chemistry, Volume 3, Issue 4, pp. 296-300 (2011)).

Alternatively, materials can be used that generate reactive \(^1\)O\(_2\) on irradiation with light, the reactive \(^1\)O\(_2\) in turn does the actual purification reaction. Such materials comprise, for example: Indocyanine green, Phthalocyanine, Methylenegreen, Sulforhadamine 101, Bengal rose, Tetraphenylporphyrine, Bacteriachlorophyll a, Coumarin 6, Coumarin 343, Coumarin 314, Coumarin 30, DCV-5T.

TiO\(_2\) is an advantageous photocatalytic material when it receives Ultra Violet (UV) light. TiO\(_2\) may also comprises C or N in its crystal structure such that TiO(2,\(x\)):C\(_x\) is
obtained or TiO\(_{2}\):N\(_y\). These from pure TiO\(_2\) derived materials are a good photocatalyst when they receive blue light.

Examples of solid state light emitters are Light Emitting Diodes (LEDs), Organic Light Emitting diode(s) OLEDs, or, for example, laser diodes. In some embodiments the solid state light source may be a blue light emitting LED, such as GaN or InGaN based LED, for example, emitting primary light of the wavelength range from 440 to 460 nm. Alternatively, the solid state light source may emit UV or violet light which is subsequently converted into light of longer wavelength(s) by one or more luminescent materials.

Fig. 2 schematically shows a cross-sectional view of another example of a lighting unit 200. The lighting unit 200 is similar to lighting unit 100, however, a housing 204 of the lighting unit 200 is made a little bit larger and a luminescent layer 202 is provided within the housing 204. The luminescent layer 202 comprises luminescent material which absorbs a portion or the light 124 or all remaining light of the first spectral range (light which remains after transmission through the photocatalytic volume 116) and converts a portion of the absorbed light towards light 206 in a second spectral range. The luminescent layer 202 is arranged at a specific position at which it receives light 124 of the first spectral range and at which it is capable of emitting the light 206 of the second spectral range through the light exit window 104 into the ambient. Optionally, the luminescent layer 202 is arranged at a position at which the air flow 120 partially flows along the luminescent layer 202 such that heat generated in the luminescent layer 202 is transported by the air flow into the ambient of the lighting unit 200.

The luminescent layer 202 is not in direct contact with the solid state light emitter 122 and there is at least a gap in between the solid state light emitter 122 and the luminescent layer 202 - the gap is filled with air, and in the example of Fig. 2 the open space between the solids state light emitter 122 and the luminescent layer 202 is partly filled with the photocatalytic volume and partly forms a channels through which the airflow 120 may flow.

In the example of Fig. 2 the luminescent layer 202 is provided within the housing at a small distance from the light exit window 104 and the transparent layer 102 forming the light exit window 104. In another optional embodiment, the light exit window does not have the transparent layer 102 and the luminescent layer 202 is provided at the light exit window 104.

The photocatalytic volume 116 of Fig. 1 and Fig. 2 comprises (glass) fibers which are arranged in a felt-like structure. In general, the photocatalytic volume may be
formed by arranging elongated elements 108 in a non-woven structure. The skilled person
knows several techniques to form non-woven structures when starting from fibers or wires.
The fibers may also be made from quartz, or may be formed by nano-wires of aluminum
oxide or aluminum. Other examples of photocatalytic volumes are presented in Figs. 3a
and 3b.

The luminescent layer 202 comprises a luminescent material which is selected
from the group of inorganic phosphors, organic phosphors and particles showing quantum
confinement and having at least in one dimension a size in the nanometer range.

The inorganic luminescent material may comprises a yellow emitting in
organic phosphor, such as, for example, YAG (Y₃Al₅O₁₂ i₂:Ce) and/or LuAG (Lu₃Al₅O₁₂), or a
red inorganic phosphor such as ECAS ((Eu,Ca)SiAlN₃ ) and/or BSSN ((Ba,Sr)₂Si₅N₈:Eu).

Examples of inorganic phosphors suitable as luminescent materials include,
but are not limited to, cerium doped yttrium aluminum garnet (Y₃Al₅O₁₂ i₂:Ce³⁺, also referred
to as YAG:Ce or Ce doped YAG) or lutetium aluminum garnet (LuAG, Lu₃Al₅O₁₂ i₂), a-
SiAlON:Eu²⁺ (yellow), and M₂Si₅N₈:Eu²⁺ (red) wherein M is at least one element selected
from calcium Ca, Sr and Ba. Another example of an inorganic phosphor that may be used in
embodiments of the invention, typically in combination with a blue light emitting light
source, is YAG:Ce. Furthermore, a part of the aluminum may be substituted with gadolinium
(Gd) or gallium (Ga), wherein more Gd results in a red shift of the yellow emission. Other
suitable materials may include (SrₓBaₐCaₚ)₂₋ₓSi₃₋ₐAlₑ₋ₐN₈₋ₐOₐ:Eu⁺²⁺ wherein 0 ≤ a < 5, 0 ≤ x
≤ 1, 0 ≤ y ≤ 1 and 0 < z ≤ 1, and (x+y) ≤ 1, such as Sr₂Si₅N₈:Eu²⁺ which emits light in the red
range

Particles of inorganic phosphors may be dispersed in a matrix polymer, such
as, for example, Polymethyl methacrylate (PMMA), Polyethylene terephthalate (PET),
Polyethylene naphthalate (PEN) or polycarbonate (PC). In other embodiments, an inorganic
phosphor forms the basis of a ceramic luminescent layer.

Organic phosphors have a high quantum efficiency and are often transparent,
which prevents undesired scattering and increases efficiency. Organic luminescent materials
have more advantages. The position and the bandwidth of the luminescence spectrum can be
designed with ease to be anywhere in the visible range. As such it is relatively easy to
manufacture a light source which emits white light with high efficacy. The white light may
be a combination of at least two colors of light, and thus the light source may comprise a
single light emitter emits light of a first color and comprise at least one organic luminescent
material converts a part of the light of the first color into a light of a second color.
The organic phosphor may be a material which comprises a perylene derivative, such as a yellow emitting perylene derivative, or a red/orange emitting perylene derivate. Such perylene derivatives are commercially available under the name Lumogen Yellow F083 or F170, Lumogen Red F305 and Lumogen Orange F240. There is a nearly unlimited assortment of such organic luminescent materials or dyes. Relevant examples are perylenes (such as dyes known under their trade name Lumogen from the company BASF, Ludwigshafen, Germany: Lumogen F240 Orange, Lumogen F300 Red, Lumogen F305 Red, Lumogen F083 Yellow, Lumogen F170 Yellow, Lumogen F850 Green), Yellow 172 from the company Neelikon Food Dyes & Chemical Ltd., Mumbai, India, and dyes such as coumarins (for example Coumarin 6, Coumarin 7, Coumarin 30, Coumarin 153, Basic Yellow 51), napthalimides (for example Solvent Yellow 11, Solvent Yellow 116), Fluorol 7GA, pyridines (for example pyridine 1), pyrromethenes (such as Pyromethene 546, Pyromethene 567), uranine, rhodamines (for example Rhodamine 110, Rhodamine B, Rhodamine 6G, Rhodamine 3B, Rhodamine 101, Sulphorhodamine 101, Sulphorhodamine 640, Basic Violet 11, Basic Red 2), cyanines (for example phthalocyanine, DCM), stilbenes (for example Bis-MSB, DPS), available from many traders. Several other dyes, such as acid dyes, basic dyes, direct dyes and dispersion dyes may be used as long as they show a sufficiently high fluorescence quantum yield for the intended use. Hence, on or more of the luminescent moieties may comprise perylene groups. Especially, one or more luminescent moieties are configured to generate red luminescence upon excitation by blue and/or UV light.

Molecules of organic phosphors may be dissolved in a matrix polymer, such as, for example, Polymethyl methacrylate (PMMA), Polyethylene terephthalate (PET), Polyethylene naphthalate (PEN) or polycarbonate (PC).

Particles showing quantum confinement and having at least in one dimension a size in the nanometer range are, for example, quantum dots, quantum rods or quantum tetrapods. Having a size in one dimension in the nanometer range means that, for example, if the particles are substantially spherical, their diameter is in the nanometer range. Or, this means that, for example, if they are wire-shaped, a size of a cross-section of the wire is in the nanometer range in one direction. A size in the nanometer range means that their size is at least smaller than 1 micrometer (e.g. smaller than 500 nanometer) and larger or equal to 0.5 nanometer. In an embodiment, the size in one dimension is smaller than 50 nanometer. In another embodiment the size in one dimension is in the range from 2 to 30 nanometer. Quantum dots are small crystals of semiconducting material generally having a width or
diameter of only a few nanometers. When excited by incident light, a quantum dot emits light of a color determined by the size and material of the crystal. Light of a particular color can, therefore, be produced by adapting the size of the dots. Most known quantum dots with emission in the visible range are based on cadmium selenide (CdSe) with shell such as cadmium sulfide (CdS) and zinc sulfide (ZnS). Cadmium free quantum dots such as indium phosphide (InP), and copper indium sulfide (CuInS2) and/or silver indium sulfide (AgInS2) can also be used. Quantum dots show very narrow emission band and thus they show saturated colors. Furthermore, the emission color can easily be tuned by adapting the size of the quantum dots. Any type of quantum dot known in the art may be used in the present invention, provided that it has the appropriate wavelength conversion characteristics.

For a specific example of a photocatalytic volume 116 reference is made to Quartzel PCO media of Saint Gobain. This is a felt made of quartz fibers and the quartz fibers are coated with a layer of TiO$_2$. Under the influence Ultra Violet light, the TiO$_2$ operates as a photocatalytic material and assists in the photoreactions between gasses which flow through the quartz felt structure. The Quartzel PCO media of Saint Gobain comprises fibers which have a diameter of 9 micrometer. Further, the product is about 15 to 22 millimeter thick, has an areal weight of 100 grams per square meter, has per gram a surface area of 120 square meter. When an air flow of a speed of 2 meters per second impinges at one of the large surface of the product and when the air flow is transmitted to an opposite surface of the product, the pressure drop across the product is 100 Pascal.

Figs. 3a and 3b schematically show examples of a photocatalytic volume 300, 350. In Fig. 3a a three dimensional view is provided of a photocatalytic volume 300 which is formed by a structure of three layers 302, 304, 306 of woven wires or fibers 308. The same type of wires or structures as discussed previously may be used, such as glass or quartz fibers or aluminum oxide or aluminum nano-wires. In Fig. 3a the three layers 302, 304, 306 are not drawn directly on top of each other, but in practical embodiments, layers of woven elongated elements are laid on top of each other.

Fig. 3b presents a cross-sectional view of another embodiment of a photocatalytic volume 350. The photocatalytic volume 350 comprises several thin rods 354 which are brought in contact with each other in an array-like structure. The rods 354 are, for example, glued or soldered to each other in an axial direction. In between the rods 354 are open spaces 352 which extends in the axial direction (of the rods 354) from one side of the photocatalytic volume 350 to an opposite side of the photocatalytic volume 350. Surfaces of
the rods 354 which face the open spaces 352 are coated with a layer of a photocatalytic material.

In alternative embodiments of the photocatalytic volume 350, the shaded circles 354 of Fig. 3b form hollow channels from one side of the photocatalytic volume 350 to an opposite side of the photocatalytic volume 350 and the surfaces facing the hollow channels are coated with the photocatalytic material. The "white" areas indicated with 352 may be a solid material. Thus, the photocatalytic material 350 may be formed by bars 352 and open spaces 354 in between the bars 352.

In an alternative embodiment of the photocatalytic volume 350, the drawn shaded circles 354 are cross-sectional views of thin tubes which touch each other in the axial direction. As well as the tubes as the spaces 352 in between the tubes form a passage for air and all surfaces of the tubes may be coated with a photocatalytic material.

Fig. 4 shows an exploded view of the interior of a lighting unit 400 which comprises LEDs in a LED on wire array arrangement 403. The lighting unit 400 comprises a fan 414, the LED on wire array arrangement 403, a photocatalytic volume 116 and a luminescent layer. The fan 414 generates an air flow 412. The air flow 412 flows towards and through the LED on wire array arrangement 403, flows through the photocatalytic volume 116 and impinges on the luminescent layer 202. The luminescent layer 202 turns the air flow 402 sideways. Although Fig. 4 does not show a housing of the lighting unit 400, the lighting unit 400 comprises at least a housing which has an air inlet near the fan 414 and an air outlet in between the photocatalytic volume 116 and the luminescent layer 202. The photocatalytic volume 116 and the luminescent layer 202 have characteristics as discussed previously. The fan generates an air flow with a high enough pressure such that the air flow is transmitted through the photocatalytic volume 116.

The LED on wire array arrangement 403 comprises a plurality of LEDs 404 which are arranged to emit, in use, light in a first spectral range. The LEDs 404 are only in contact with wires 406, 408 and are not provided on a layer which has the function of a supporting surface. The LEDs 404 are coupled to each other with the wires 406, 408 and the wires 406, 408 are strong enough to support the LEDs 404. Thereby, a relatively flexible and thin structure of wires 406, 408 and LEDs 404 is provided. The wires 408 in a first direction provide a first supply voltage and the wires 406 in a second direction perpendicular to the first direction provide a second supply voltage to the LEDs 404. At two ends of the LED on wire array arrangement 403 the wires 406, 408 in different directions are connected to power supply lines 410. The LED on wire array arrangement 403 has an open structure which
allows the air flow to freely flow through the LED on wire array arrangement 403 and which allows the cooling of the LEDs 404 in an optimal way.

Fig. 5a shows a three dimensional view of an exterior of a lighting unit 500. The lighting unit 500 comprises a light tube 506 which is at least partly transparent such that a light exit window 510 is obtained. At a first end of the light tube an air flow creation unit 504 is provided which comprises holes 502 through which air is drawn into the light tube 506. At a second end of the light tube, which is opposite the first end, the purified air 508 leaves the air tube through holes. Thus, the air inlet is formed by the holes 502 and the air flow creation unit 504, and the air outlet is formed by holes at the second end (not shown). The light tube 506 may be made of, for example, glass or of a synthetic material. At least a portion of the light tube 506 is light transmitting and has the function of light exit window. The light exit window may be transparent or translucent.

Figs. 5b and 5c show cross-sectional views of a lighting unit 500 of Fig. 5a along line A-A'. Fig. 5b presents a first embodiment with a photocatalytic volume 534 in a light reflective arrangement and Fig. 5c presents a second embodiment with a photocatalytic volume 564 in a light transmissive arrangement.

The cross-sectional view 530 of Fig. 5b shows that, within the light tube 506, a TLED strip 538/536, two photocatalytic volumes 534 and a luminescent element 532 are provided. All the elements within the light tube 506 have an elongated shape and extend within the light tube 506 in an axial direction. The TLED strip 538/536 comprises an elongated supporting strip 538 (which may be a printed circuit board) on which a plurality of LEDs 536 are provided which emit light in a first spectral range in a direction away from the TLED strip 538/536. The LEDs 536 may have a Lambertian angular light emission distribution and, therefore, some light is also emitted in a sideward direction towards the photocatalytic volumes 534. The photocatalytic volumes 534 are, for example, made of fibers which comprise at their surface a photocatalytic material. The photocatalytic volumes 534 are configured such that they, at least, partially reflect light which impinges on the fibers which photocatalytic material. For example, when the density of fibers in the photocatalytic volume 534 is relatively large and, for example, TiO₂ is provided as a photocatalytic material, the TiO₂ reflects and scatters light and, consequently, a portion of the light which is reflected back into the light tube is also emitted towards the luminescent element 532. The luminescent element 532 at least comprises a layer of luminescent material which converts light of the first spectral range towards light of the second spectral range. Depending on specific characteristics of the photocatalytic material and of the luminescent element 532 the
light emission of the lighting unit of Fig. 5b may comprises light of the first spectral range and of the second spectral range, or it may only comprises light in the second spectral range.

The cross-sectional view 560 of Fig. 5c represents a lighting unit which is similar to the lighting unit 530 of Fig. 5b and which has also the discussed elements of the lighting unit 500 of Fig. 5a. However, the lighting unit 560 of Fig. 5c comprises another luminescent element 562 and another photocatalytic volume 564. The photocatalytic volume 564 is arranged in between the TLED strip 538/536 and the luminescent element 562. The photocatalytic volume 564 may be a woven or non-woven elongated elements made of very thin wires or made of fibers which comprises a photocatalytic material at their surfaces. The density of the photocatalytic volume 564 is chosen such that light which enters the photocatalytic volume 564 at a first side is (at least partly) transmitted through the photocatalytic volume 564 to a second side of the photocatalytic volume 564. The transmission through the photocatalytic volume 564 may also include the reflection and scattering of the light. Thus, light which impinges on the luminescent element 562 is at least partly transmitted through the photocatalytic volume 564. The luminescent element 562 comprises at least a layer of luminescent material which converts light of the first spectral range towards light in a second spectral range.

The lighting units 500, 530, 560 of Figs. 5a, 5b, 5c may be configured to be used in a traditional luminaire which is suitable for traditional discharge tubes. Thus, the lighting units 500, 530, 560 may have at both ends two pins to connect to the mains power and the lighting units 500, 530, 560 may comprise an additional electric circuit to convert the power which is received via those two pins towards power which is suitable to use with the LEDs.

Fig. 6 schematically shows an interior of a room 600 comprising two luminaires 604, 606 according to the second aspect of the invention. At a ceiling 602 of the room 600 a luminaire 604 is provided which comprises lighting units according to the first aspect of the invention. For example, light tubes according to the embodiments of Figs. 5a, 5b or 5c are provided in the luminaire 604. At a wall 608 of the room 600 is provided a wall-luminaire which comprises a lighting unit according to the first aspect of the invention. The luminaires 604, 606 provide, beside illumination of the room 600, also the advantageous effect of air purification. This may be useful in, for example, houses or offices. It is to be noted that, for example, in an office, the air inlet of the lighting unit(s) may be coupled to the air outlet of the air-conditioning system which is present in the office building such that the air-conditioning system provides the air flow of the lighting unit. It might also be that the air-
conditioning system of the building comprises an air inlet for drawing away air from the offices such that the air may be circulated to other placed in the building. The air outlet of the lighting unit may be coupled to the air inlet of the air-conditioning system such that the pressure at the air outlet of the lighting unit decreases and such that an air flow starts to flow from the air inlet of the lighting unit to the air outlet of the lighting unit.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims.

In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention may be implemented by means of hardware comprising several distinct elements. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.
CLAIMS:

1. A lighting unit (100, 200, 400, 500, 530, 560) for illumination and for purifying air, the lighting unit (100, 200, 400, 500, 530, 560) comprising
- an air inlet (118) for receiving an air flow (120, 412),
- an air outlet (112),
- a solid state light emitter (122, 404, 536) for emitting light (124) in a first spectral range, the solid state light emitter (122, 404, 536) being arranged between the air inlet (118) and the air outlet (112) such that, in use, at least a portion of the air flow (120, 412) flows along the solid state light emitter (122, 404, 536),
- a photocatalytic volume (116, 300, 350, 534, 564) comprising multiple elongated structures (108, 308, 354) with a photocatalytic material on a surface of the elongated structures (108, 308, 354), the photocatalytic volume (116, 300, 350, 534, 564) being configured to allow the air flow to flow through the photocatalytic volume (116, 300, 350, 534, 564), the photocatalytic volume (116, 300, 350, 534, 564) being arranged between the air inlet (118) and the air outlet (112) such that, in use, at least a portion of the air flow flows through the photocatalytic volume (116, 300, 350, 534, 564), and the photocatalytic volume (116, 300, 350, 534, 564) being arranged to receive light (124) emitted by the solid state light emitter (122, 404, 536), the photocatalytic material being configured to be a catalyst in photoreactions between gasses in the air flow (120, 412) under the influence of light being comprised in the first spectral range, and
- a light exit window (104, 510) for transmitting visible light into an ambient of the lighting unit (100, 200, 400, 500, 530, 560).

2. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 1 further comprising a luminescent layer (202, 532, 562) comprising a luminescent material, the luminescent material being arranged to absorb a portion of the light (124) of the first spectral range and to convert a portion of the absorbed light into light (106, 206) of a second spectral range, the luminescent layer (202, 532, 562) being arranged to receive light (124) emitted by the solid state light emitter and to emit the light (106, 206) of the second spectral range at least partially towards the light exit window (104, 510).
3. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 2, wherein a gap is present between the luminescent layer (202, 532, 562) and the solid state light emitter (122, 404, 536) and wherein the luminescent layer (202, 532, 562) and the solid state light emitter (122, 404, 536) are arranged such that, in use, a portion of the air flow flows through the gap.

4. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 1 or 2, wherein the photocatalytic volume (116, 300, 350, 534, 564) is configured to be at least partially light transmitting and is arranged to transmit light (124) emitted by the solid state light emitter (122, 404, 536) before the emitted light (124) reaches the light exit window (104, 510) into the ambient or, when referring to claim 2, before the emitted light (124) impinges on the luminescent material.

5. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 1 or 2, wherein the photocatalytic volume (116, 300, 350, 534, 564) is configured to be at least partially light reflective and is arranged to reflect light (124) emitted by the solid state light emitter (122, 404, 536) before the emitted light (124) is transmitted through the light exit window (104, 510) into the ambient, or, when referring to claim 2, before the emitted light impinges on the luminescent material.

6. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 1, wherein the first spectral range comprises light in the visible spectral range.

7. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 1, wherein the photocatalytic material comprises TiO$_2$.

8. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 1, wherein the elongated structures (108, 308, 354) are fibers.

9. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 8, wherein the photocatalytic volume (116, 300, 350, 534, 564) is a woven or non-woven material made of the fibers.
10. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 8 or 9, wherein the fibers are one of glass fibers, quartz fibers, aluminum oxide nano-wires or aluminum nano-wires.

11. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 1, the elongated structures (108, 308, 354) are bars or wires of aluminum oxide or aluminum having a cross-sectional diameter which is smaller than 1 millimeter.

12. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 1 or 2 comprising a plurality of solid state light emitters (404) for emitting light of the first spectral range and wherein the plurality of solid state light emitters (404) are arranged in a LED on wire array (403).

13. A lighting unit (100, 200, 400, 500, 530, 560) according to claim 1 or 2 further comprising
- a tube (506) of a light transmitting material and
- a plurality of solid state light emitters (536) for emitting light of the first spectral range,
and wherein
- the air inlet (118) is arranged at a first end of the tube (506)
- the air outlet (112) is arranged at second end of the tube (506), the second end being opposite the first end,
- the light exit window (510) is at least a portion of the tube (506),
- the plurality of solid state light emitters (536) are arranged on a TLED strip (538/536) which is arranged in the tube (506),
- the photocatalytic volume (534, 564) having an elongated shape and is arranged in the tube (506),
and, when referring to claim 2, the luminescent layer (532, 562) having an elongated shape and is arranged in the tube (506).

14. A lighting unit according to claim 1 wherein the lighting unit (100, 200, 400, 500, 530, 560) comprises an air flow creator (414) for providing an air flow (120, 412) to the air inlet (118).
15. A luminaire (604, 606) comprising a lighting unit (100, 200, 400, 500, 530, 560) according to any one of the claims 1 to 14.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. F21V29/02 A61L9/20 F21S4/00 F21V9/06
ADD. F21S8/00 F21Y101/02 F21Y103/00

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)
F21V A61L F21S F21Y

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

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<td>JP 2009 295578 A (ADVANCED OPTOELECTRONIC TECH) 17 December 2009 (2009-12-17) figures 1, 2, 9 -----</td>
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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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Date of the actual completion of the international search 8 May 2014

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Thi Baut, Arthur
## DOCUMENTS CONSIDERED TO BE RELEVANT

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