

DEVICE, SYSTEM AND METHOD FOR PROVIDING DISINFECTION

TECHNICAL FIELD

5 **[0001]** The present disclosure relates to a device, system, and method for providing disinfection.

BACKGROUND

10 **[0002]** The following discussion of the background is intended to facilitate understanding of the present disclosure. However, it should be appreciated that the discussion is not an acknowledgment or admission that any of the material referred to was published, known or a part of the common general knowledge in any jurisdiction as at the priority date of the application.

15 **[0003]** In view of the outbreak of infectious diseases, there exists an increased need for scheduled and routine cleaning. In particular, it has become nearly essential for routine disinfection of public or commonly accessed areas. There is also a general expectation for such disinfection to be done quickly and effectively so as to minimise disruptions to operations. However, there is at present no 'continuous' cleaning solutions that enable people to continue functioning while a premise/room is being disinfected.

20 **[0004]** Existing solutions for providing disinfection include devices equipped with ultraviolet (UV) radiation emitters as a means for providing disinfection. However, existing solutions suffer from various limitations such as inadequate coverage of UV radiation emitters, inadvertent exposure of UV to living beings, and inadequate heat management of UV light emitters. In addition, there is
25 generally a need for personnel to exit a premise when disinfection takes place, to avoid or minimize exposing personnel to the harmful UV rays. Such down time causes inconvenience and can adversely affect productivity.

[0005] There exists a need for an improved apparatus and/or system for providing disinfection, without comprising on operations and productivity.

SUMMARY

[0006] According to one aspect of the disclosure, there is a device for disinfection of an area, the device comprises a collimator comprising a cone portion and an elongate portion, the cone portion shaped and dimensioned to receive an LED (light emitting diode) array or a laser diode and mountable onto the a surface via a mounting assembly; and the elongate portion operable to reflect, diffract, or deflect light rays emitting from the LED array to form a narrowed light beam; wherein the LED array or laser diode comprises at least one UV-C emitter, and wherein the elongate portion comprises a nozzle having an opening for the narrowed light beam to exit therefrom, and an internal surface coated with light reflective material.

[0007] In some embodiments, the light reflective material comprises polished aluminum and/or polished aluminum alloy.

[0008] In some embodiments, the at least one UV-C emitter is operable to emit a wavelength of about 270 nanometers to 280 nanometers, and preferably at a wavelength of about 278 nanometers (nm).

[0009] In some embodiments, the polished aluminum alloy comprises at least 80% aluminum, and preferably is an aluminum alloy comprising aluminum, chromium, and magnesium.

[0010] In some embodiments, the mounting assembly may include a base plate. The base plate, collimator, and nozzle may be integrally moulded. The integrally moulded device may be formed by an extrusion process or an additive manufacturing process.

[0011] In some embodiments, the nozzle opening has a width of about 4 mm.

[0012] In some embodiments, the device comprises at least one intensity sensor arranged to detect the intensity of the UV-C emission.

[0013] According to another aspect of the disclosure there is a system for disinfection of an enclosed area having walls and a ceiling, comprising a

collimator mounted on a first wall surface or from a ceiling via a mounting assembly, at a height from the ceiling; the collimator containing an UV-C emitter and operable to emit a narrowed beam of UV-C radiation through a nozzle opening; and a plurality of UV-C radiation sensors mounted on a second wall surface for detection the UV-C radiation emitted from the collimator; wherein the plurality of UV-C radiation sensors are arranged to detect at least two levels of UV-C radiation corresponding to two different regions of the second wall.

[0014] In some embodiments, the collimator is at least part of the device for disinfection of an area.

[0015] In some embodiments, the plurality of UV-C radiation sensors may include one or more radiation dosimeters, one or more UV-C electronic sensors, and/or one or more dosimeter cards.

[0016] In some embodiments, the UV-C radiation sensors are arranged to detect three levels of UV-C radiation corresponding to three different regions of the second wall, wherein the three level comprises a first level associated with a UV-C radiation intensity capable of disinfection, a second level associated with a stray UV-C radiation intensity, and a third level associated with a no UV-C radiation intensity.

[0017] In some embodiments, the system comprises a feedback network to stop emission of the UV-C radiation if the second level exceeds a predetermined threshold.

[0018] In some embodiments, the collimator is positioned at a height in a range of 100mm to 300mm from the ceiling. It is found that such a height achieves a compromise between an effective disinfection (aided by air circulation), and safety (i.e. stray UV-C radiation exposed to living beings is minimized due to the positioning of the collimator at a height that is much higher than the average height of a human being).

[0019] In some embodiments, there comprises a first ratio of an illumination width by the narrowed beam of UV-C radiation projected on the second wall (a)

to a distance of a nozzle opening to the UV-C radiation sensors (b) is equals to
ta second ratio of a nozzle width (x) to a distance of the UV-C emitter to the
nozzle opening ($a/b = x/y$).

5 [0020] According to another aspect of the disclosure there is a method for
providing disinfection to an enclosed area having walls and a ceiling,
comprising the steps of: providing a collimator mounted on a first wall surface
at a predetermined height from the ceiling; the collimator containing an UV-C
emitter and operable to emit a narrowed beam of UV-C radiation through a
nozzle opening; providing a plurality of UV-C radiation sensors mounted on a
10 second wall surface for detection the UV-C radiation emitted from the
collimator; wherein the plurality of UV-C radiation sensors are arranged to
detect at least two levels of UV-C radiation corresponding to two different
regions on the second wall.

15 [0021] Other aspects of the disclosure will be apparent to those of ordinary
skill in the art upon review of the following description of specific embodiments
of the disclosure in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

20 [0022] Various embodiments are described, by way of example only, with
reference to the accompanying drawings, in which:

[0023] Figures 1a to 1d show an embodiment of a device for providing
disinfection.

[0024] Figures 2a and 2b show another embodiment of a device

25 [0025] Figures 3a to 3c show one or more embodiments of a system for
providing disinfection.

[0026] Figure 4 shows a method of providing disinfection.

[0027] Figure 5 shows a setup of a device for providing disinfection in a room.

[0028] Other arrangements are possible, and it is appreciable that the accompanying drawings are not to be understood as superseding the generality of the preceding description of the disclosure.

5 DETAILED DESCRIPTION

[0029] Embodiments are described with reference to the accompany drawings. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the present disclosure. Other definitions for selected terms used herein may be found within
10 the detailed description of the disclosure and apply throughout the description. Additionally, unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one ordinary skilled in the art to which the present disclosure belongs. Where possible, the same reference numerals are used throughout the figures for clarity and
15 consistency.

[0030] Throughout the specification, unless the context requires otherwise, the word “comprise” or variations such as “comprises” or “comprising”, will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

20 [0031] Throughout the specification, unless the context requires otherwise, the word “include” or variations such as “includes” or “including”, will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0032] Throughout the specification, unless the context requires otherwise,
25 the word “have” or variations such as “has” or “having”, will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0033] As used herein, the term “disinfection”, “disinfecting”, “disinfectant” and variants refer to the use of a method to at least minimize

bacteria/germs/virus of an area/premise. The terms include methods via physical, chemical contact and/or via exposure to radiation (e.g. exposure to the area to specific radiation such as ultra-violet radiation). The term 'air disinfection' may be construed as a disinfection method to minimize
5 bacteria/germs/virus in the air flowing within the area/premise.

[0034] As used herein, the term "associate", "associated", "associate", and "associating" indicate a defined relationship (or cross-reference) between at least two items. For instance, a plurality of devices (e.g. in the form of disinfection device/apparatus) may be controlled by a central server/processor
10 and hence 'associated' with the central server/processor. In a group of devices, each device may interact with another device and hence be associated with one another.

[0035] As used herein, the term "network" can be any means of providing communication between one or more devices and/or content stored elsewhere.
15 As used herein, network can be a personal area network, local area network, a storage area network, a system area network, a wide area network, a virtual private network, and an enterprise private network. The network can include one or more gateways or no gateways. The network communication can be conducted via published standard protocols or proprietary protocols.

[0036] As used herein, communication of data through any network can be:
20 (i) encoded or unencoded; (ii) encrypted or unencrypted; (iii) delivered via a wired network, a wireless network, or a combination of wired and wireless. Wireless communication can be accomplished in any practical manner including a Wi-Fi 802.11 network, a Bluetooth™ network, or mobile phone
25 network (such as 3G, 4G, LTE, and 5G). The terms "connected", "connected", and "connecting" as used herein refer to a communication link between at least two devices and can be accomplished as discussed in this paragraph.

[0037] As used herein, the term "computing device" may be a single stand-alone computer such as a desktop computer or a laptop computer, a thin client,
30 a tablet computer, or a mobile phone. The computing device may run a local

operating system and store computer files on a local storage drive. The computing device may access files and application through a gateway to one or more content repositories, the content repository can host files and/or run virtual applications and generate a virtual desktop for the computing device.

- 5 **[0038]** As used herein, the term “server” or “processor” may include a single stand-alone computer, a single dedicated server, multiple dedicated servers, and/or a virtual server running on a larger network of servers and/or cloud-based service. The processor may include integrated circuit (IC) chips such as application specific integrated circuit (ASIC) chips.
- 10 **[0039]** As used herein, the term “database” may include one or more data repositories to store data and access data from a single stand-alone computer, a data server, multiple dedicated data servers, a cloud-based service, and/or a virtual server running on a larger network of servers.
- 15 **[0040]** As used herein, the term “sensor” or “sensors” include hardware sensors, software sensors and combinations of hardware and software sensors.
- [0041]** As used herein, the terms ultraviolet-C and “UV-C” include, but is not limited to all UV-C radiation, short-wave ultraviolet, FAR-UV, deep UV etc. A UV-C radiation may be at a wavelength of 200 to 280 nanometres (nm).
- 20 **[0042]** As used herein, the term “photocatalytic material” and “photocatalyst” are used interchangeably and refers broadly to any material that absorbs electromagnetic radiation such as UV radiation to bring it to a higher energy level and provides such energy to a reacting substance to make a chemical reaction occur.
- 25 **[0043]** As used herein, the term “ceiling” refers to an upper interior surface of an enclosed area, such as a room, or other similar compartment. The ceiling is not limited by shape and does not necessarily has to be a flat surface.

[0044] With reference to Figures 1a to 1d, there is a disinfection device 100. Figure 1a is a perspective view of the disinfection device 100, Figure 1b is an exploded view of the disinfection device 100 showing salient components, Figure 1c shows a side cross-sectional view of the disinfection device 100 viewed from a direction C1 and Figure 1d shows another cross-sectional view viewed from a direction C2.

[0045] The disinfection device 100 may be mounted onto a surface or mounted from a surface via a mounting assembly. In some embodiments where the disinfection device 100 is mounted onto a wall surface, the mounting assembly may comprise a base plate 102 shaped and dimensioned for mounting onto the wall surface.

[0046] The disinfection device 100 comprises a collimator comprising a cone portion 106 and an elongate portion 108, the cone portion 106 shaped and dimensioned to receive an LED (light emitting diode) array 110 and mountable onto the base plate 102; and the elongate portion 108 operable to reflect, diffract, or deflect light rays emitting from the LED array 110 to form a narrowed light beam; and the elongate portion 108 forms a nozzle and comprises an opening 112 for the narrowed UV-C radiation (light) beam to exit therefrom. The LED array 110 comprises at least one UV-C emitter, and wherein the elongate portion comprises an internal surface coated with light or radiation reflective material.

[0047] The base plate 102 may be a metallic plate adapted to be mounted onto a wall surface. As the LED array 110 comprising one or more UV-C emitter(s) is in turn mounted onto the base plate 102, the base plate 102 is preferably formed from or of an anti-corrosion material such as aluminum or aluminum alloy. Other metals/materials may be considered, provided these are able to withstand the corrosive irradiation of UV-C radiation. In some embodiments the base plate 102 comprises means to receive fasteners such as screws or nails for attachment to a wall surface.

The cone portion 106 may function as a radiation mixing chamber. An interior surface of the cone portion 106 may be coated with a light or radiation reflective material to facilitate the diffraction/deflection/reflection of UV-C radiation incident onto the interior surface of the cone portion 106 before the UV-C radiation is sent to the elongate portion 108. The cone portion 106 may comprise a tapered part 114 which is shaped and adapted to receive the elongate portion 108.

[0048] The elongate portion 108 may be substantially rectangular in shape and adapted to be attached to the cone portion 106. and comprises a hollow portion 116 adapted for UV-C radiation to pass through when in operation. The inner surface of the elongate portion 108 defining the hollow portion 116 is suitably coated with light or radiation reflective material to facilitate the collimation of UV-C radiation within the hollow portion 116, which tapers off to form the nozzle opening 112. The elongate portion 108 may form the nozzle.

[0049] In some embodiments, as an alternative or in addition to LED array 110, one or more UV-C laser diodes may be used.

[0050] A plurality of fasteners 118, such as screws, may be used to attach the various components to each other. For example, fasteners may be used to attach the LED array 110 to the base plate 102. Fasteners may also be used to attach the cone portion 106 to the base plate 102. The cone portion 106 may be attached to the elongate portion 108 via the tapered part 114 which may function as a flange.

[0051] Although Figures 1a to 1d show the various components as different parts, it is contemplated that the device 100 may be integrally molded. In particular the device may be molded via an extrusion process. As an alternative, the device 100 may be manufactured via an additive manufacturing process, such as, but not limited to, 3D printing.

[0052] It is appreciable that the dimensions of various components may affect one or more properties or parameters of the collimated radiation. It is therefore

contemplated that the overall length of the device 100 may be in a range of 30mm to 100mm. The length of the elongate portion 108 may be around 40 mm, the nozzle width may be in a range of 2 mm to 4 mm.

5 [0053] It is contemplated that the entire device may be formed from an aluminum alloy, such as, but not limited to, a 5052-aluminum alloy. The internal surface where the UV-C radiation passes may be polished to increase the reflectivity of the said surface.

10 [0054] Referring to Figures 2a and 2b, there is illustrated another embodiment of disinfection device 150. Figure 2a is a perspective view of the disinfection device 150, Figure 2b is an exploded view of the disinfection device 150 showing salient components.

15 [0055] The disinfection device 150 comprises a base plate 152 for mounting onto a surface, a collimator comprising a cone portion 156, the cone portion 156 shaped and dimensioned to receive an LED (Light emitting diode) array 160 and mountable onto a heatsink 162

20 [0056] Each LED on the array 160 may be enclosed by an optical lens unit 164. In some embodiments, the optical lens unit 164 may be formed from or of liquid silicone rubber (LSR). Each optical lens unit 164 is configured to converge emitted radiation from the respective LED to form a narrowed light beam. At least one of the LED may be a UV-C radiation emitter. In some embodiments, the elongate portion comprises an internal surface coated with light, radiation reflective material. In some embodiments, the elongate portion may be coated with a photocatalyst, such as titanium dioxide (TiO₂) nanoparticles. The lens units 164 may be held in position via a lens holder 168, which may be attached to the LED array 160 via fasteners such as screws as known to a skilled person.

[0057] The base plate 152 may be metallic plate adapted to be mounted onto a wall surface. The LED array 160 comprising one or more UV-C emitters is in turn mounted onto a heatsink 162, the heatsink 162 may be formed from or of an anti-corrosion material such as aluminum or aluminum alloy. Other metals /

materials may be considered, provided the contemplated materials are resistant to the corrosive irradiation of UV-C radiation.

5 [0058] The cone portion 156 functions as a radiation mixing chamber. A portion of the cone 156, such as an interior surface of the cone portion 156, may be coated with a light or radiation reflective material to facilitate the diffraction/deflection/reflection of UV-C radiation incident onto the interior surface of the cone portion 156 before the UV-C radiation is directed to the elongate portion. In some embodiments, the cone portion 106 may be coated with a photocatalyst, such as titanium dioxide (TiO₂) in powdered or
10 nanoparticle form.

[0059] A nozzle 158 is adapted to be attached to the cone portion 156, and comprises a hollow portion adapted for UV-C radiation to pass therethrough when in operation. The inner surface of the nozzle 158 defining the hollow portion may be coated with light or radiation reflective material to facilitate the
15 further collimation of UV-C radiation within the hollow portion.

[0060] In some embodiments, as an alternative or in addition to LED array 160, one or more UV-C laser diodes may be used.

[0061] In some embodiments, as an alternative or in addition to optical lens unit 164, one or more optical devices (not shown) for adjusting the beam angle
20 of the emitted radiation may be utilized.

[0062] The device 150 may be driven by a power supply, in the form of a driver 170 configured to produce relatively ripple-free current. In some embodiments, the power supply may be in the form of a switch mode power converter as described in PCT publications WO/2011/152795,
25 WO/2013/066270, and/or WO/2019/032053. The LED driver 170 may be held in place by a driver bracket 172 which functions as a driver cover. The driver bracket 172 may be formed from or of a polycarbonate material. The driver bracket 172 may be attached to the heatsink 162 together with the LED array 160. The driver bracket 172 may be held in place by fasteners 174, which may

include side bracket made from aluminum material and designed with a plurality of holes, e.g. three holes, to facilitate mounting angle adjustments.

5 [0063] In some embodiments, one or more parts of the device 100, 150, for example the housing, may be formed from or of plastic coating with ultraviolet radiation stabilizers.

[0064] The coating of the photocatalyst for device 150 may also be applied to various parts of the device 100. The coating may comprise titanium dioxide (TiO₂) in various form. In some embodiments, the titanium dioxide may comprise nanoparticles and applied to various parts of the devices 100, 150 in
10 the form of a coat, a film or powder.

[0065] It is contemplated that the UV-C emitter used in combination with photocatalytic materials may further mitigate airborne microbial contaminations. For example, Titanium Dioxide (TiO₂) irradiated by UV-C radiation may release negatively charge anions, which in turn react with water in the air to form
15 hydroxyl-OH ions. These hydroxyl-OH ions attack organic molecules (e.g. viruses and bacteria) and turn them to harmless substances like carbon and water. Such arrangement may be suited for devices with LED arrays 110, 160 having LEDs emitting radiation of different wavelengths. For example, the LED array may comprise one or more LEDs emitting radiation in the visible light
20 wavelength and one or more LEDs emitting UV-C radiation that can be used to irradiate the photocatalysts.

[0066] In some embodiments, the nozzle of the device 100 and/or device 150 has a length of about 30mm, 40mm or 80mm.

25 [0067] In some embodiments, the device 100 and/or device 150 may comprise one or more adjustable bracket for adjusting an angle of tilt with respect to a surface in a range of 0 degree to ± 20 degrees.

[0068] In some embodiments, the LED array 110 or 160 may comprise at least one LED for providing an indication of an operational status of the device 100 or 150.

[0069] According to another aspect of the disclosure there is a system for disinfection of an area, such as a room. In particular, the system can operate without need for personnel or people to leave the room or premise when disinfection is carried out. In another aspect, the system may also be regarded
5 as a system for calibrating a UV-C radiation apparatus or device so that safe disinfection can carry out without adverse effects to human beings.

[0070] Figure 3a shows a system 200 for disinfection of an enclosed area having walls and a ceiling. The illustration in Figure 3a shows the enclosed area in the form of an office area, but it is understood that the enclosed area may be
10 other premise such as, but not limited to, a residential room, a warehouse, an auditorium.

[0071] The system 200 comprises a collimator 202 mounted on a first wall surface 204 at a height 206 from the ceiling; the collimator 202 containing an UV-C emitter and operable to emit a narrowed beam of UV-C radiation through
15 a nozzle opening. The collimator 202 may be the device 100 or the device 150, or part thereof.

[0072] The system 200 may comprise a plurality of UV-C radiation sensors 210 mounted on a second wall surface 208 for detection the UV-C radiation emitted from the collimator 202. The second wall surface 208 may be a wall
20 surface directly opposite the first wall surface 204 and facing the first wall surface 204. Each of the plurality of UV-C radiation sensors 210 may be mounted at a specific height from the floor. As a non-limiting example, the plurality of UV-C radiation sensors 210 may be mounted at a height of 0.9 meters (m) to 2.9 m.

[0073] The plurality of UV-C radiation sensors 210 are arranged to detect at
25 least two levels of UV-C radiation. The two levels of UV-C radiation may correspond to two different regions of the second wall surface 208. As shown in Figure 2a, the UV-C radiation sensors, in the form of dosimeter cards, may be positioned on the second wall surface in a manner such as to detect the

intensity of UV-C radiation detected at different regions on the second wall surface 208.

5 **[0074]** As shown in Figure 3b, the two regions of the second wall surface 208 may correspond to a first region 212 where the detected UV-C radiation is sufficiently strong to deactivate organisms such as viruses and perform disinfection functions (i.e. at a radiation fluence of $10 \mu\text{W}/\text{cm}^2$ or more), and a second region 214 where UV-C radiation is detected but at a weak intensity. The first region 212 is known as a germicidal or 'kill' zone. The second region 214 is known as a stray zone.

10 **[0075]** In some embodiments, the UV-C radiation sensors may be arranged to detect three levels of UV-C radiation corresponding to three different regions/zones on the second wall. The three level corresponds to the first region 212, the second region 214, and a third region 216 associated no UV-C radiation intensity.

15 **[0076]** Although the UV-C radiation sensors 210 are in the form of dosimeter cards, it is contemplated that one or more of the UV-C radiation sensors may include at least one of a radiation dosimeter, a UV-C electronic sensor as alternatives or in addition.

20 **[0077]** In some embodiments (not shown), the system 200 may comprises a feedback network to stop emission of the UV-C radiation if the UV-C radiation intensity detected at the second region 214 exceeds a predetermined threshold. The predetermined threshold, also referred to as safe fluence (when using a dosimeter card), may be at $0.2 \mu\text{W}/\text{cm}^2$.

25 **[0078]** In some embodiments, the collimator 202 may be positioned at a height in a range of 100mm to 300mm from the ceiling.

[0079] Figure 3c shows a calculation of a first ratio and a second ratio, used for calibration of the device 202. The first ratio is based on an illumination width generated by the narrowed beam of UV-C radiation projected on the second wall (a) to a distance of a nozzle opening to the UV-C radiation sensors (b). The

second ratio is that of a nozzle width (x) to a distance of the UV-C emitter to the nozzle opening (y).

[0080] For proper calibration, the ratio a/b is equals to the ratio x/y ($a/b = x/y$).

[0081] It is contemplated that for a larger room where the distance between the first wall and second wall remains relatively constant, the disinfection coverage may be increased by having multiple devices 202 arranged adjacent each other. In some embodiments, the width of a device 202 may be 500 mm, and depending on the room size, one or more additional devices 202 may be added for increased disinfection coverage.

[0082] According to another aspect and as shown in Figure 4, there is a method 300 for providing disinfection to an enclosed area having walls and a ceiling, comprising the steps of: providing a collimator mounted on a first wall surface at a predetermined height from the ceiling (step S302); the collimator containing an UV-C emitter and operable to emit a narrowed beam of UV-C radiation through a nozzle opening; providing a plurality of UV-C radiation sensors mounted on a second wall surface for detection the UV-C radiation emitted from the collimator (step S304); wherein the plurality of UV-C radiation sensors are arranged to detect at least two levels of UV-C radiation corresponding to two different regions on the second wall.

[0083] Optionally, the method 300 comprises a step of calibrating the collimator (step S306) in accordance with the mathematical equation:

$$a/b = x/y$$

wherein **a** is the illumination width generated by the narrowed beam of UV-C radiation projected on the second wall; **b** is the distance of the nozzle opening to the UV-C radiation sensors on the second wall; **x** is the width of the nozzle opening; and **y** is the distance of the UV-C emitter to the nozzle opening.

[0084] It is contemplated that the device 100, system 200, and method 300 may be applied to systems and methods for calibrating and detecting UV-C

radiation to demonstrate effectively of disinfection and/or mitigating safety hazard. For example, the system 200 may comprise UV-C radiation sensors capable of transmitting data to one or more servers through a network. If any safety requirement is breached, e.g. then the UV-C radiation level detected by the UV-C radiation sensors exceed certain predetermined settings, the device 202/100 will be switched off.

[0085] In some embodiments, the one or more servers may be arranged in data or signal communication with the collimator 202 to perform automatic disinfection of the enclosed area. The one or more servers may include a remote controller for sending signals to the collimator 202 to control the emission of radiation of each of the LED on the LED array. Alternatively, the one or more servers may send control signals to the LED driver, which may include an in-built controller, of the collimator 202. The collimator 202 and UV-C radiation sensors 210 may exchange data over a network.

[0086] In some embodiments, the one or more servers may be configured as an administrator device to send control signals to the collimator 202 and sensors 210, and in turn receive data from the collimator 202 and sensors 210. In some embodiments, such data may be in the form of heartbeat signal(s) and or status signal indicating the operation status of the collimator 202 and sensors 210. The administrator device may further include an intelligent module to implement offline and/or online scheduling. Where the sensors 210 are in the form of one or more dosimeter cards, there may comprise at least one image capturing device, in the form of a camera, to capture colour change associated with the one or more dosimeter cards and send the captured images to the one or more servers.

[0087] In some embodiments, the device 100 and/or device 150 has a linear form shape and may have a length of in the range from 200mm to 550mm.

[0088] It is contemplated that one or more computing devices may be used by a user to remotely control the device 202 and/or receive data from the UV-C radiation sensors 210.

[0089] Figure 5 shows a set-up 500 for measuring radiation emitted by a device 150. A radiation receiver 502 may be arranged in an optical path 504 of the LED array 160 to receive emitted radiation from the LED array 160, and the radiation measurement obtained and specified distances away from the device 150, for example at 1 metre, 2 metres, 3 metres, 4 metres, and 5 metres, etc. The radiation receiver 502 may be mounted on a support platform, such as a tripod structure 506. The radiation receiver 502 may be a radiation sensor as described in other embodiments.

[0090] While the described embodiments show the devices 100 and 150 as wall mounted devices, it is contemplated that the devices 100 and/or 150 may be ceiling mounted (not shown). In one embodiment, the mounting assembly for such ceiling mounted device may include one or more retractable/adjustable cables attached from the ceiling and attachable to a top or side portion of the device 100 or device 150. In another embodiment, the mounting assembly may include one or more telescopic extension poles attached from the ceiling and attachable to a top or side portion of the device 100 or device 150. It is further contemplated that one or more markings or indicators may be made on the adjustable cables/ telescopic extension poles to indicate a height measurement with respect to the ceiling surface.

[0091] It is further contemplated that each device 100 or device 150 may comprise two or more LED arrays or drivers.

[0092] It is to be appreciated by the person skilled in the art that variations and combinations of features described above, not being alternatives or substitutes, may be combined to form yet further embodiments falling within the intended scope of the invention.

CLAIMS

1. A disinfection device comprising

5 a collimator comprising a cone portion and an elongate portion, the cone portion shaped and dimensioned to receive a light emitting diode (LED) array or a laser diode and mountable onto a surface via a mounting assembly; and the elongate portion operable to reflect, diffract, or deflect light rays emitting from the LED array to form a narrowed light beam; and

10 wherein the LED array or laser diode comprises at least one UV-C emitter, and wherein the elongate portion comprises a nozzle having an opening for the narrowed light beam to exit therefrom, and the elongate portion comprises an internal surface coated with light/radiation reflective material.

2. The device of claim 1, wherein the light reflective material comprises polished aluminum and/or polished aluminum alloy.

15 3. The device of claim 1 or 2, wherein the at least one UV-C emitter is operable to emit a wavelength of about 270 nanometers to 280 nanometers.

4. The device of claim 2, wherein the polished aluminum alloy comprises at least 80% aluminum, and preferably is an aluminum alloy comprising aluminum, chromium, and magnesium.

20 5. The device of any one of the preceding claims, wherein the mounting assembly comprises a base plate, and the base plate, the collimator and the nozzle are integrally molded.

6. The device of claim 5, wherein the device is formed by an extrusion process or an additive manufacturing process.

25 7. The device of any one of the preceding claims, wherein the nozzle opening has a width of about 4 mm.

8. The device of any one of the preceding claims, wherein the device comprises at least one intensity sensor arranged to detect the intensity of the UV-C emission.
9. The device of any one of the preceding claims, wherein an internal surface
5 of the collimator is coated with a photocatalyst.
10. A system for disinfection of an enclosed area having walls and a ceiling, comprising
- a collimator mounted on a first wall surface or from a ceiling via a mounting assembly, at a height from the ceiling; the collimator containing an
10 UV-C emitter and operable to emit a narrowed beam of UV-C radiation through a nozzle opening; and
- a plurality of UV-C radiation sensors mounted on a second wall surface for detection the UV-C radiation emitted from the collimator;
- wherein the plurality of UV-C radiation sensors is arranged to detect at
15 least two levels of UV-C radiation corresponding to two different regions on the second wall.
11. The system of claim 10, wherein the collimator is a device of any one of claims 1 to 9.
12. The system of claim 10 or 11, wherein the plurality of UV-C radiation
20 sensors include at least one of a radiation dosimeter, a UV-C electronic sensor, a dosimeter card.
13. The system of claim 10, wherein the UV-C radiation sensors are arranged to detect three levels of UV-C radiation corresponding to three different regions on the second wall, wherein the three level comprises a first level associated
25 with a UV-C radiation intensity capable of disinfection, a second level associated with a stray UV-C radiation intensity, and a third level associated with a no UV-C radiation intensity.

14. The system of claim 13, further comprises at least one server arranged in signal communication with the collimator and to receive data from the plurality of UV-C radiation sensors via a feedback network, the at least one server operable to send a signal to stop emission of the UV-C radiation if the second
5 level exceeds a predetermined threshold.

15. The system of any one of claims 10 to 14, wherein the collimator is positioned at a height in a range of 100mm to 300mm from the ceiling.

16. The system of any one of claims 10 to 15, wherein a first ratio of an illumination width by the narrowed beam of UV-C radiation projected on the
10 second wall (a) to a distance of a nozzle opening to the UV-C radiation sensors (b) is equals to a second ratio of a nozzle width (x) to a distance of the UV-C emitter to the nozzle opening ($a/b = x/y$).

17. The system of any one of claims 10 to 16, further comprises an image capturing device configured to capture images associated with each of the
15 plurality of UV-C radiation sensors.

18. A method for providing disinfection to an enclosed area having walls and a ceiling, comprising the steps of:

providing a collimator mounted on a first wall surface or a mounted from the ceiling at a predetermined height from the ceiling; the collimator containing
20 an UV-C emitter and operable to emit a narrowed beam of UV-C radiation through a nozzle opening;

providing a plurality of UV-C radiation sensors mounted on a second wall surface for detection the UV-C radiation emitted from the collimator; and

arranging the plurality of UV-C radiation sensors to detect at least two
25 levels of UV-C radiation corresponding to two different regions on the second wall.

19. The method of claim 18, wherein the step of arranging the plurality of UV-C radiation sensors is to detect three levels of UV-C radiation corresponding to three different regions on the second wall.

20. The method of claims 16 or 17, wherein the three different regions
5 correspond to a germicidal zone, a stray zone, and a no-radiation zone.