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(71) Applicant: **ICAP HOLDING B.V.** [NL/NL]; Industrieweg 70, 8071 CW Nunspeet (NL).

(72) Inventors: **ZONDAG, Louis John**; P/A Leap Holding B.V., Industrieweg 70, 8071 CW Nunspeet (NL). **SMIT, Harm Jaap**; P/A Leap Holding B.V., Industrieweg 70, 8071 CW Nunspeet (NL). **BEIJERT, Oscar**; P/A Leap

Holding B.V., Industrieweg 70, 8071 CW Nunspeet (NL). **LUCHTMEIJER, Walewein Wederic**; P/A leap Holding B.V., Industrieweg 70, 8071 CW Nunspeet (NL).

(74) Agent: **EDP PATENT ATTORNEYS B.V.**; Bronland 12E, 6708 WH Wageningen (NL).

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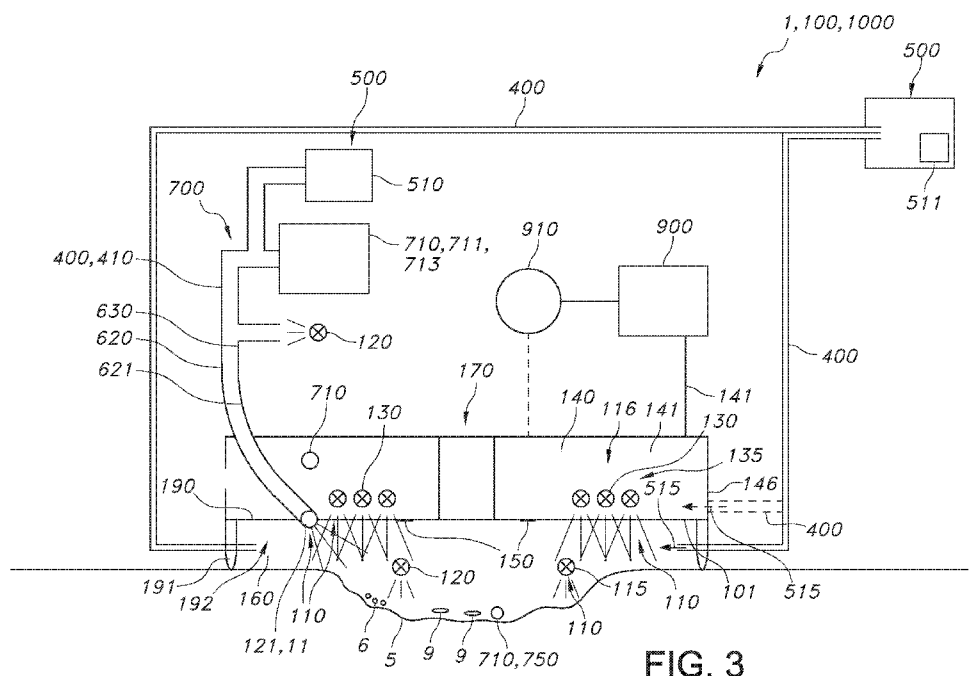


FIG. 3

(57) Abstract: The invention relates to a treatment system (1) for treating a wound (5) of a subject, wherein the treatment system (1) comprises a treatment arrangement (1000), wherein the treatment arrangement (1000) comprises a treatment cap (100) comprising a first face (101) configured for arranging the treatment cap (100) over the wound (5) and for contacting skin tissue (2) surrounding the wound (5) thereby defining a treatment space (160) between the wound (5) and the treatment cap (100), wherein the treatment arrangement (1000) further comprises at a side of the first face (101) an illumination area (110) configured for providing light (11) at the wound (5).

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Intelligent cap for skin tissue treatment

FIELD OF THE INVENTION

5 The invention relates to a treatment system for treating a wound. The invention further relates to a treatment arrangement. The invention further also relates to a treatment cap, which may be comprised by the treatment system. Yet further, the invention relates to a method for producing a treatment cap. The invention further relates to a use of the treatment system.

BACKGROUND OF THE INVENTION

10 Wound treatment systems are known in the art. WO03003989, for instance, describes a wound healing device comprising a housing, a corona and/or ultra-violet light generating member, ultrasonic wave generator, and/or a photoactivatable material. The housing includes a cavity and at least one opening. The member for generating corona and/or ultra-violet light within the cavity of the housing includes a surface corona discharge device and a power supply associated therewith. The photoactivatable material is positioned within the cavity of the housing. The device further comprises an ultrasonic wave generator and/or oxygen generator within the cavity of the housing. The member for generating corona and/or ultra-violet light within the cavity of the housing includes a surface corona discharge device and a power supply associated therewith. The photoactivatable material is positioned within the cavity of the housing.

20 WO03070135, for instance, describes a device for treating a wound in the skin of a patient by exposing the wound to a medium which stimulates the healing process, which device comprises at least one wall which can be connected in an at least substantially fluid-tight manner to skin tissue surrounding the wound so as to form an at least substantially fluid-tight space between the wound and the wall, a fluid inlet for introducing said medium into said space, and a fluid outlet, wherein the wall area that is to cover the wound is provided with spacers extending towards the wound, which spacers are intended to rest on the wound so as to keep at least part of the wall spaced from the wound.

SUMMARY OF THE INVENTION

30 Skin tissue may be injured and damaged in many ways. It can be caused by a traumatic event such as an abrasion, cut or contusion. It can also be caused by an

underlying chronic condition such as immobility, neuropathy, diabetes, peripheral arterial disease and many more. If the damaged or injured tissue has an open connection to the outside of the body, it may be called a wound. Minor wounds can mostly be treated at home by washing and/or disinfecting the wound and removing the dirt and debris. Yet, larger or

5 severe damage of the skin may require medical assistance. Medical professionals may use many different techniques to treat a wound and after cleaning, an open wound may be closed or be left open depending on the status of the wound. Different systems may further be used to clean and/or treat the wound. However, it appears that often the healing process takes a longer period than anticipated or healing may start but the process stalls after a

10 while. Occasionally, it is understood why the healing does not takes place as expected and a healing protocol may be changed. In other cases, however, it is not understood why the treatment does not work or it is recognized too late that the treatment does not work as anticipated, e.g., because a medical professional only assesses the state of the wound every couple of days. Moreover, a wound healing process may comprise a “cascade of healing”

15 consisting of four partly overlapping phases. The first phase begins on the onset of injury and is called the hemostasis phase. In the hemostasis phase the body activates its emergency repair system and the bleeding is stopped by the body. The second phase is called the inflammatory phase and essentially is directed to preparing the wound bed for growth of new tissue. In the third phase, the proliferative phase, the wound is filled and covered. The

20 last phase is called the maturation phase. In this phase, collagen fibers slowly reorganize, and tissue remodels and matures. In all phases different processes may take place that may also need different treatment therapies. Prior art therapies seem not to be able to address events in relation to the phase the wound is in. Furthermore, wounds that extend from the exterior of the body into the interior of the body, may require more than a topical treatment.

25 For instance, tunneling (bed) sores can be particularly difficult to treat; and may require extensive medical treatment. Additionally, cells of the located further away from the injured cells may not need the same treatment to heal than cells in the core of the wound.

Presently used systems, do not seem to be able to solve the problems. Hence, it is an aspect of the invention to provide an alternative treatment system for treating a

30 wound of a subject, that preferably further at least partly obviate(s) one or more of the above-described drawbacks. In further aspects a treatment arrangement and a treatment cap are provided, that preferably further at least partly obviate one or more of the above-described drawbacks. In a further aspect, the invention provides a method for treating (and/or assessing) a wound, that preferably further at least partly obviate(s) one or more of

the above-described drawbacks. The invention further provides a method for producing a treatment cap or treatment arrangement as described herein.

The present invention may have as object to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

5 In a first aspect, the invention provides a treatment system for treating wound of a subject. The treatment system may comprise a treatment arrangement, comprising a treatment cap, especially comprising a first face configured for arranging over the wound and especially for contacting (non-damaged) skin tissue surrounding the wound, thereby defining a (sealed) treatment space between the wound and the treatment cap (and
10 the (non-damaged) skin tissue surrounding the wound). The treatment arrangement especially comprises at a side of the first face an illumination area configured for providing light at the wound. Especially, the first face is configured for arranging the treatment cap over the wound.

 The treatment system may further comprise one or more actuators
15 configured for treating the wound. Examples of actuators are a lighting system that may generate the light (directly or indirectly), a fluid handling system, e.g. for supply or withdrawal of a fluid to or from the treatment space, a (mechanical) compression system for (controlling the treatment space and) connecting the first face to the wound (see further below). The compression system may especially provide a compression to the wound (and
20 surround areas).

 Hence, the treatment system (and the method) is configured for treating a wound, especially for cleansing the (damaged) skin and/or for improving the healing process of the (damaged) skin tissue, by means of one or more, especially a plurality of, actuators. Additionally or alternatively, the treatment system (and the method) is
25 configured for managing the wound bed and the involved tissue (see below).

 Moreover, the treatment system may provide an improved treatment of a wound (or “damaged skin tissue” / “injury to the skin”, see further below) compared to prior art solutions. The improved treatment system may provide a treatment based on the use of a plurality of actuators. In embodiments, the system may be configured for
30 personalized treatment, wherein the treatment (especially a treatment protocol) may be changed or adapted during use of the system, for instance based on a (sensed or determined) status of the wound and/or a status of the healing process of the wound. The treatment system may be used to cleanse a wound. The treatment system may be applied for supporting the healing process. The healing process may, e.g., be enhanced by providing a

mechanical pressure (compression) and a (closed) protective cover on the wound, especially artificially providing a scab or a crust. The treatment system (and the method) may especially be configured for adapting to the prevailing phase(s) (of the cascade of phases) of the wound healing process at a determined moment. Especially, the treatment system may be configured to exert influence on the individual and different cell types in the wound bed and at specific moments in the healing cascade. Herein, the wound healing process may also be indicated as a “healing cascade” or “cascade of healing”. The healing process may further be enhanced by removing harmful microorganisms and/or stimulating microorganism that are useful for the healing process.

10 The system may comprise different actuators acting on different modalities. Moreover, the treatment system may further comprise one or more sensors, especially sensing the status of the wound. The system may be used for assessing (a healing process of) a wound (with or without treating the wound). Hence, also the term “treatment” as in “treatment system” and treatment arrangement” and “treatment cap” may in embodiments
15 relate to “assessment” or “inspection” The word “treatment” (in these elements) may in embodiments be replaced by “inspection” or assessment”. The treatment system may be used for a topical treatment and/or inspection of a wound, especially of a skin breach. The treatment system may further be used for a treatment and/or assessment of a wound extending from the topical region of the body into the interior of the body, such as an
20 abscess cavity or a tunneling bed sore.

 The treatment system may comprise a control system. The treatment system may be configured for controlling treating of the (damaged) skin tissue, especially for controlling the one or more actuators, e.g. in a control mode, (by the control system) e.g. based on a (combination of) signal(s) of the sensor(s). Furthermore, the control system may
25 comprise a self-learning control system.

 The treatment system comprises a treatment arrangement comprising a treatment cap. The treatment system, the treatment arrangement and/or the treatment cap may be used in a method for treating a wound, as described herein (see further below). Herein, the term “system” may also be applied for “the treatment system” of the invention.
30 Furthermore, the terms “arrangement” and “apparatus” may relate to “the treatment arrangement” and the terms “cap” and “device” may be used to refer to “the treatment cap”.

 The treatment cap may comprise a plurality of parts. In embodiments, the treatment cap is composed of the plurality of parts. The treatment cap may e.g. comprise a raised edge comprising a central opening configured for arranging (the raised edge) at the

(undamaged) skin surrounding the wound, especially completely enclosing the wound (wherein the raised edge may not contact the wound). In other embodiments, the raised edge may be part of a (closed) layer comprising the raised edge. As such, the raised edge may define a cavity at or in the layer (or the combination of the layer and the raised edge define the cavity). A sheet or wall may be arranged in (and connected to) the raised edge, wherein the central opening or the cavity is (sealingly) closed. As such, the sheet and the raised edge may define the treatment space at a first side of the sheet, when being arranged over the wound (see further below). Yet, the raised edge may (also) further be closed by the sheet and a further rim may be configured at the sheet and/or at the raised edge, protruding from the sheet and/or raised edge at a side away from the raised edge. As such, a combination of the further rim and the sheet may define of the treatment space (when being arranged over the wound). In embodiments, the sheet or wall defines the treatment space during use. The sheet or wall, especially at a border of the sheet or wall, may be configured for providing a sealingly contact with the skin (when being arranged over the wound). In embodiments, a cover may be arranged over the raised edge at a second side (being different from the first side) of the sheet, thereby defining a fluid chamber between the raised edge, the sheet and the cover. Yet, in other embodiments, the cavity in the layer and the sheet may define the fluid chamber (see further below). The raised edge and/or the layer /and/or the cover may be configured to provide stability to the treatment cap. In further embodiments, the treatment cap comprises (or is associated to) a frame to provide stability. The raised edge and/or the further rim may further be configured for providing a sealingly contact between the raised edge and the skin. A material of the sheet and of the raised edge may not be the same. The sheet may comprise a resilient material, whereas the material of the raised edge is more rigid than the material of the sheet. The sheet may be flexible. Yet, in embodiments, the raised edge or part of the raised edge (and/or the further rim) may (also) comprise a resilient material, and especially the raised edge (and/or further rim) may be flexible. The flexibility of the treatment cap, especially of the different parts may allow the compressing contact (during the compressing period) between the first face and the wound. Hence, the treatment cap may comprise a plurality of parts as depicted in the above given embodiments. The treatment cap may e.g. comprise two parts (elements), three parts, four parts, up to 10 parts and even more. In a specific embodiment, the treatment cap comprises a monolithic treatment cap. Further parts will be discussed below.

The term “a wound” as in “for the treatment of a wound” and the like, may especially relate to an injury including an injury to a skin and/or a damaged (skin) tissue

and/or a skin breach. The wound may comprise an ulcer and/or a tunneling wound. Hence, especially the wound may relate to one or more injuries selected from the group consisting of a wound, an infected wound, a venous leg ulcer, an arterial leg ulcer, an abrasion, a lesion, a sore, a pressure ulcer, a tunneling wound, a burn wound, a radiation wound, a
5 diabetic ulcer, and a neuropathic ulcer. When treating the wound, especially (also) surroundings of the wound may be treated (see also below). Hence, the treatment may not only involve management of the damaged tissue, but also management of the surrounding tissue which is involved in the wound healing process.

The wound may be visible as a skin breach. The wound may (partly or
10 completely) be located at an exterior side of a body part of the subject. The terms “wound”, “damaged skin tissue”, and “injury to the skin” described herein, however, are not restricted to the skin breach, and/or exterior and/or visible, and/or topical part of the wound. In embodiments, the wound may comprise a subcutaneous wound. In specific embodiments, the subcutaneous wound may not be in fluid contact with the exterior of the body. Yet, also
15 such wound may be treated such as with the light e.g. if the skin covering the wound is transmissive for the light. As such, the light may still be provided at the wound (the damaged tissue). The wound may (partly) comprise a subcutaneous wound. The wound may at least comprise the skin breach. In embodiments, the wound further extends from the (skin or) exterior of the body part into (the interior of) the body part of the subject. For
20 instance, in tunneling wounds, the wound extends to the interior of the body part. Hence, the wound may comprise a cavity, such as an abscess cavity in the body part. A cavity may be a simple straight cavity. Yet a cavity may comprise a number of tunnel tracks. The tunnel may comprise curves. The tunnel may comprise a tortuous tunnel track. Embodiments of the treatment system, especially the treatment arrangement, even more especially the
25 treatment cap, are configured for treating and/or inspecting a wound as described herein. The treatment cap is especially configured for arranging over such wound, and (thereby) defining the treatment space between the treatment cap and the wound. The treatment space may thus be delimited (or enclosed) by the treatment cap. The treatment space may comprise (a side of) the first face. The treatment space, further may be delimited by the
30 wound (especially tissue of the wound) and (undamaged) skin surrounding the wound that is enclosed by the treatment cap. In embodiments, the treatment space (also) comprises (or extends to) a cavity and/or a tunnel of a tunnel wound or another interior wound (see further below).

Herein, the term “subject” may relate to a human having an injury, especially an injury to the (human) skin comprising a wound. Yet, the subject may also be an animal (having such injury). The subject may be a patient. The treatment system may be used and/or configured for treating a wound in a skin of an animal. Furthermore, the term “skin” will be understood by the skilled person. The term especially relates to a (thin) layer of tissue forming a natural outer covering of a body of a vertebrate, especially a person or animal (especially, with respect to the present application, of the subject). The skin especially comprises an epidermis (layer) (in contact with the exterior of the body) and a dermis (layer) (arranged between the epidermis and the subcutaneous tissue (or hypodermis) (of the body)). A breach in the skin may comprise a breach in the epidermis (only), as well as a breach in the epidermis and in the dermis (and in the subcutaneous tissue below the skin in the body).

When being used, the treatment cap may comprise at least part of the one or more actuators and/or one or more sensors. In embodiments, the treatment system may be assembled before use. Hence, in embodiments, the cap comprises an actuator and/or sensor such as described herein. In further embodiments, the arrangement comprises the actuator and/or sensor. The actuator and/or sensor may be (detachably) hosted by the arrangement. In further embodiments, the actuator and/or sensor may be detachably hosted by the cap. Herein, the terms “the actuator” and “the sensor” may especially relate to more than one (different) actuator and to more than one (different) sensor, respectively. During the treatment, the one or more actuators may be actuated independently from each other. Moreover, also a period of activation of the one or more actuators may be selected independently from each other. The system is especially configured for such treatment.

The term (detachably) hosted will be understood by a person skilled in the art. If a first element is (detachably) hosted by a further element, the further element at least partly hosts the first element, but it may also be detached therefrom. In embodiments, the further element completely comprises (detachably) the first element. In other embodiments, the further element only partly comprises (or holds) the first element (detachably). The first element may further be detached from the further element. For that, the further element may e.g. comprise a socket configured for (detachably) hosting or holding the (respective) first element. Furthermore, the first element may be configured for attaching and detaching to the further element. For instance, a press fit or Snap-on /snap-off means may be applied for attaching and detaching. The one or more actuators and the one or more sensors

described herein are examples of the first element. The system, arrangement, and cap may be examples of the further element.

The treatment system may comprise a lighting system configured to generate the light, especially, configured to generate light having a wavelength selected from the range of 100-1100 nm, especially to provide the light at the wound. The lighting system may be configured to directly generate the light. Additionally or alternatively, the lighting system may be configured to indirectly generate the light, see further below. The lighting system is especially optically coupled with the illumination area.

In embodiments, the (an) actuator comprises the lighting system. Hence, the system may comprise the lighting system. In embodiments, the arrangement, especially the treatment cap, comprises at least part of the lighting system. The lighting system may e.g. be detachable hosted by the treatment arrangement, especially by the treatment cap. The lighting system is especially configured for emitting (the) light from the illumination area, especially the light provided (downstream of the illumination area) at the wound. Herein the light (in the treatment space and traveling to the wound) may also be referred to as “the light generated” or “the light generated at the illumination area” or “light emitted at the illumination area” or “light emitted from the illumination area” or “light downstream from the illumination area”. The light may differ from light upstream of the illumination area, or light emitted at a light source comprised by the lighting system, see also below. The term “illumination area” may also refer to a plurality of (different) illumination areas. These illumination areas may spatially be different.

By actuating the lighting system, light may be emitted from the illumination area, especially to the wound. The light may be emitted inside the wound. Additionally or alternatively, the light may be emitted to location outside (surrounding) the wound. The light is especially emitted to the tissue engaged with the wound (“involved tissue”). For that, the lighting system may be configured to provide light to the illumination area, directly or indirectly. Hence, light may be emitted upstream of the illuminating area (by, especially a light source of, the lighting system), propagate or be guided to the illumination area, and successively the light may be emitted from the illuminating area (as the light generated) to the wound. As such, the illumination area may function as a location (or a plurality of locations) for transmitting the light. The light source may be arranged for illuminating the illumination area. In embodiment, the lighting system and/or the illumination area may be configured for providing the light (also) at skin tissue surrounding the wound.

Herein the term “involved tissue” may be used for tissue directly and indirectly engaged with the wound, i.e. the tissue of the wound as well as tissue surrounding the wound, e.g. tissue located within in a range of 1-5 cm, especially within 3 cm distance of the wound. Such tissue may comprise cells that may differ from skin cells in normal undamaged skin, and may also need a treatment to heal.

The illumination area may completely be arranged at the first face (of the treatment cap). Though in other embodiments, none or only part of the illumination area is arranged at the first face. In embodiments, at least part of the illumination area is arranged at a distance (of the first side) at the side of the first face. The illumination area may e.g. project or protrude from the first face. Hence, the term “at a side” in “at a side of the first face” may comprise the first face as well as locations (in the treatment space) arranged at a distance from the first face and especially projecting or protruding from the first face. At least a part of the illumination area may be arranged in a cavity, such as a tunnel of a tunnel wound (see further below).

The light may be generated outside the treatment cap, being guided to the illumination area, such as by a light guide. Successively, the light may be emitted from the illumination area. A light guide may functionally couple the lighting system to the illumination area. The light guide may e.g. comprise a light guide selected from the group consisting of a glass fiber, a quartz fiber, and a hollow fiber. Yet, other guides are also possible, as long as the guide may guide light emitted by (a light source of) the lighting system. For guiding/reflecting the light emitted by the lighting system, the hollow fiber may comprise a reflective inner wall, e.g. comprising a reflective coating and/or material.

At least part of the light guide may (detachably) be hosted by the arrangement, e.g., by a light guide socket. In embodiments, the light guide may be plugged in the cap.

Additionally or alternatively, the light may be directly generated at the illumination area by the lighting system that may at least partially be arranged at the illumination area (see below).

In further embodiments, light emitted by the lighting system and the light generated, i.e. light emitted by the illumination area, may not be the same. The illumination area may e.g. comprise a material that changes light passing through the illumination area. The material may e.g. absorb some light (wavelengths) such that the light downstream of the illumination area differs from light upstream of the illumination area, especially of light emitted by the lighting system. Moreover, the light emitting area may comprise a light

(wavelength) converter. Light emitted by the lighting system may e.g. be converted by the light converter, such as a quantum dot, to the light (provided from the illumination area). Such quantum dot or other type of light converter (e.g. arranged at the illumination area) may receive light with a first wavelength and emit light with a second wavelength. In such
5 embodiment, the light generated at the illumination area may comprise light with the second wavelength. Also other embodiments may be possible wherein the light downstream from the lighting system but upstream of the illumination area is at least partly converted to light with the second wavelength.

Hence, in embodiments, the treatment system further comprises a light
10 guide, wherein the light guide is configured to functionally connect the lighting system to the illumination area. In further embodiments, the treatment arrangement, especially the treatment cap, comprises a light guide socket for detachable hosting at least part of the light guide. Hence, at least part of the lighting system may be arranged external from the treatment cap, especially from the treatment arrangement.

15 The light (that may be) generated at the illumination area may comprise a wavelength selected from the range of 100-1100 nm, especially from the range of 200-1100 nm, such as 200-900 nm. The wavelength may be selected from the range of 130-280 nm. The wavelength may further (also) be selected from the range of 280-1000 nm, especially from the range of 300-900 nm. The term "a wavelength" and similar terms may refer to a
20 single wavelength, i.e. laser-like, or a plurality of different wavelength, like an emission band.

In embodiments, the light comprises (at least) (wavelengths together making up) white light. White light is known to the skilled person and may contain a combination of wavelengths of visible light, especially having a wavelength in the range of 400-700 nm.
25 White light may further be accompanied with invisible light, such as light having a wavelength selected from the range of 100-400 nm and/or from the range of 700-1100 nm, such as selected from the different ranges described herein.

The light may be generated to stimulate metabolic processes in the cell (in and/or surrounding the wound). The (white) light may e.g. activate redox reactions in
30 (metal-containing) proteins in the metabolic system of the cell. The (white) light may (also) be generated in order to assess (the status of) the wound (see further below).

In specific embodiments, the light comprises a plurality of wavelengths. For instance, the light may comprise a wavelength selected from the range of 100-280 nm, especially 200-280 nm, such as 207-222 nm for its antimicrobial effect. The light may

comprise a wavelength selected from the range of 300-400 nm for its effect on cell proliferation and division. The light may further comprise a wavelength selected from the range of 600-700 nm to stimulate healing of the wound and/or reduce inflammation. Alternatively or additionally, the light may comprise a wavelength selected from the range of 660-890 nm to stimulate blood circulation. Hence, the light may comprise light (or a wavelength) selected from the group consisting of UV light (especially deep UV/UVC, UVB and/or UVA), visible light, and infrared light.

To differentiate between light spectra's, herein the terms "first light" and "second light" may be used. The term "first light" may especially relate to light comprising a wavelength selected from the range of 100-280 nm, especially from deep UV light. The term "second light" may relate to light comprising a wavelength selected from the range of 280-1100 nm. In other embodiments, the first light is selected in the range of 100-1100 nm. The first light may especially be equal to or larger than 100 nm, such as equal to or larger than 150 nm, especially equal to or larger than 225 nm, and especially equal to or smaller than 500 nm, such as equal to or smaller than 300 nm, especially equal to or smaller than 275 nm. In further embodiments, the second light is selected in the range of 100-1100 nm. The second light may especially be equal to or smaller than 1000 nm, such as equal to or smaller than 950 nm, especially equal to or smaller than 750 nm, and especially equal to or larger than 200 nm, such as equal to or larger than 300 nm, especially equal to or larger than 650 nm.

When two or more types of light are provided, with wavelengths selected from different wavelength ranges, the two or more types of light have different spectral distributions. Hence, the second light especially has a spectral distribution being different from the one of the first light.

Hence, the lighting system may comprise a first light source configured to generate the first light (at the illumination area). Alternatively or additionally, the lighting system comprises a second light source configured to generate the second light (at (and emitted from) the illumination area). As the term "illumination area" may also refer to (spatially) different illumination areas, the different types of light may in embodiments emanate from (spatially) different illumination areas.

The term "light" as in "light", "first light", "first light source", "second light", "second light source" and combinations like "generated light", "emitted light", "primary light" and the term "wavelength" described herein may in embodiments relate to more than one light and/or light source and/or more than one wavelength.

In embodiments, the lighting system is configured to generate first light (at (and emitted from) the illumination area) having a wavelength selected from the range of 100-280 nm, such as selected from the range of about 230-280 nm. In further embodiments, the lighting system is (also) configured to generate second light (at the illumination area) having a wavelength selected from the range of 280-1100 nm. The light especially comprises the first light and the second light. When the light that is provided to the skin may be varied in spectral distribution, such as by using two or more different types of light source, the light provided to the skin may differ in time. For instance, the spectral distribution may e.g. be controlled in dependence of a sensor signal (see also below). The light that is provided to the skin may in embodiments be varied in energy distribution. This may e.g. be based on a (total) time of illumination. Additionally or alternatively, an intensity of the light may be controlled. Hence, the light (spectrum) provided to the skin may have a distribution over time and/or over wavelength (during the treatment process).

The first light source and/or the second light source may comprise different types of light emitting devices. In a specific embodiment, the first light source and/or the second light source comprises a light emitting diode (LED) (for generating the light having a determined wavelength). Moreover, the first light source and/or the second light source may comprise an array of (a plurality of) light emitting diodes (LEDs). In embodiments, the first light source comprises a first array of LEDs. In further embodiments, the second light source comprises a second array of LEDs. The first array of LEDs may be configured for generating the first light, especially having a plurality of wavelength selected from the range of 100-280 nm, such as selected from the range of about 230-280 nm. The second array of LEDs may be configured for generating the second light, especially having a plurality of wavelength selected from the range of 280-1100 nm.

In embodiments, the treatment system is configured for treating the damaged tissue and the surrounding (non-injured but) involved tissue with light comprising wavelengths and/or light intensities adapted to the cells in the tissue. An open wound (bed) may roughly be described as having four types of tissue (cells). In a first region comprising the center (core) of such wound, the cells may especially be damaged (these cells may eventually be covered by dead cells). In a second region (three dimensionally) surrounding the damaged cells, the cells may be injured. In a third region, (three dimensionally) surrounding the second region, the cells may (only) be stressed. In a fourth region, (three dimensionally) surrounding the third region, the cells may (only) still be adapted (from normal skin cells). These respective different types of cells (damaged, injured, stressed and

adapted) may in embodiments be treated using a respective treatment method, such as a respective light treatment. Hence, the system may be configured for treating at least one of the different types of cells different from the other types of cells, such as emitting with a different wavelength (spectrum).

5 Damaged cells may e.g. be treated with light having a broad spectrum, e.g. comprising wavelengths in the range of 100-1100 nm, especially in the range 280–1100 nm. Damaged cells may especially be treated with light having wavelengths at least from 280-500 nm. Injured cells (injured tissue) may be treated with light having wavelengths in the range of 500-1100 nm, especially in the range of 280-700 nm. In further embodiments, 10 the injured cell may advantageously be treated with light having wavelengths in the range of 500-600 nm. Stressed cells may in embodiments advantageously be treated with light having wavelengths from 600-1100 nm.

Hence, the treatment system may be configured for providing the light with different wavelength at (the location of) the different cell types. In a specific embodiment, 15 the light sources of the (second) light source are arranged in a spatial configuration in the system (especially in the treatment cap, especially in the chamber). The light sources (such as LEDs) may e.g. be arranged in spatial arrangement corresponding to the contours of the wound. The light sources may be arranged in a circular fashion. In an embodiment a central light source, especially emitting a light in the range of 100-1110 nm, especially in the range 20 of 200- 700 nm, may be arranged in the center of the arrangement of light sources. A further set of light sources may be arranged around the center (as a first ring or first other contour) and may be configured for emitting light with wavelength from 200 to 1100 nm, especially from 280-1100 nm, even more especially from 600-1100 nm. A set of light sources may be arranged surrounding the first set of light sources and may be selected for providing light 25 having wavelengths in the range of 400-700 nm, such as 500-600 nm. In a further embodiment, a further (third) set of light sources may be arranged even further remote from the center light source(s) surrounding the second set of light sources. This further (third) set of light sources may especially be configured for providing the light having a wavelength, especially a plurality (all) of the wavelength, selected from the range of 280- 30 500 nm. A such, a specific spectrum of light (having different wavelengths) may be provided to different locations of the wound and the involved tissue. The different wavelengths may have different effects on the healing of the wound. The different wavelengths may be directed to different topical locations of the wound and the involved tissue. The different wavelengths further may penetrate the tissue over a different

penetration length (under the skin and/or topical area of the wound). In embodiments, the first set of light sources may be configured for providing the light to the stressed cells, and especially also to the injured cells and the damaged cells (and optionally to the topical area of adapted cells). The second set of light sources may in embodiments be configured for providing the light to the injured cells, and especially also to the damaged cells (and optionally to the topical area of adapted and stressed cells). The third set of light sources may be configured to provide the light to the damaged cells (and optionally to the topical area of other cells). Additional sets of light sources may further be arranged surrounding the third set of light sources. The sets of light sources especially are configured in the chamber. The sets especially comprise second light sources, especially providing light to the wound via the wall of the chamber. Yet the sets may in embodiments comprise first light sources. Herein the term “set” in set of light sources may relate to more than one light source, such as 2, 3, 4, 5, 6. In embodiments, at least one of the sets may comprise more than 6 light sources.

Hence, in an embodiment the (second) light sources comprise a plurality of sets of (second) light sources, each configured for emitting a respective wavelength (spectrum). Especially the sets of light sources are configured for arrangement corresponding with the contours of the wound, such as in a circular fashion (in (the chamber of) the treatment cap). The respective sets are especially arranged (and the wavelengths are especially selected) in relation to their *modus operandi*. The sets of light sources are especially configured based on the status of cells in the wound that are provided with the light of the light source.

The center light source may especially comprise a flashlight, emitting pulsed light. The center light source may in embodiments emit white light.

In further embodiments, the first light source is configured for generating the first light as one or more of a pulsed light, and a continuous light. A pulsed light may be generated for varying an applied dose of light. Additionally or alternatively, the second light source is configured for generating the second light as one or more of a pulsed light, a continuous light, a polarized light, and a combination of polarized light and unpolarized light. The term “polarized light” may relate to linearly polarized light and (left or right) circularly polarized light.

Pulsed light, especially high intensity pulsed light may advantageously be used in the treatment to initiate and facilitate biochemical (healing) processes in the tissue. Molecules in the cells may react to the light. Especially providing a number of pulses

(flashes) may result in an improved effect relative to providing the same amount of energy with a continuous light. Not being bound to theory, it is hypothesized that providing a large change in the light provided to the molecules (such as binary change of on/off) is more relevant for some molecules than an providing a determine amount of light to the molecule.

5 The pulsed light (the flashlight) may in embodiments especially comprise a very broad spectrum of wavelength, such as from 100 to 1100 nm, especially from 400-700 nm, more especially comprising (the wavelengths together defining) white light. Different wavelengths in the broad spectrum may affect different molecules in the wound. The different wavelengths may initiate and/or facilitate different biochemical processes

10 Polarized light may, e.g., trigger the cellular and humoral defence mechanisms of the human organism (also known as “photo modulation”). Both quality and quantity of neutrophil granulocytes may increase resulting in improved phagocytosis. Moreover, lymphocytes, monocytes and eosinophils (not present prior to illumination) may appear in wound smears. Alternatively, or additionally polarized light may facilitate a
15 quantitative increase in immunoglobulins and other proteins, especially resulting in a higher rate of healing. Furthermore, especially right circularly polarized light and linearly polarized light may promote the process of wound healing by increasing the proliferation of fibroblasts. A right circularly polarized light may increase an expression of type 1 procollagen mRNA. Without being bound to theory, it is hypothesized that some optical
20 active material, especially having a circular dichroic spectrum, may take part in a biochemical reaction as a result of a circular polarization.

As discussed above, the light emitted by the first and/or second light source may be converted to the light generated at the illumination area. The first light source and/or the second light source are especially functionally coupled to the illumination area. The
25 first light source and/or the second light source may (partly) be arranged external from the treatment cap and/or the treatment arrangement.

Hence, (one of) the actuator(s) may comprise the first light source and/or the second light source. In embodiments, the treatment arrangement, especially the treatment cap, comprises one or more of the first light source and the second light source. In further
30 embodiments, the first light source and/or the second light source is/are (detachable) hosted by the treatment arrangement, especially by the treatment cap.

The first light source may be functionally connected to the illumination area by the light guide, especially the first light may be provided at the wound. By actuating the first light source, the first light may be provided at the wound. If the treatment cap (the first

face of the treatment cap) is not (or only partly) transmissive for light emitted by the first light source, the light guide may, e.g., be inserted through the treatment cap for functionally connecting the first light source to the illumination area. As such, the illumination area may comprise a light guide tip of the light guide, such as a tip of a glass fiber, a quartz fiber, or a hollow fiber (for emitting the light). Additionally or alternatively, the first light source may be arranged in the treatment space. The first light source may e.g. directly be arranged at (a tip of) a fiber or a tube or another (elongated) body. The first light source may comprise a (elongated) body for arranging the first light source in the treatment space. In embodiments, the body may (also) be arranged through the treatment cap. In embodiments, the first light source may be arranged at a determined location in the treatment space during or after arranging the treatment cap over the wound. As such, the first light source (and especially also part of the illumination area) may (also) be arranged in a cavity or tunnel of e.g. a tunnel wound. In further embodiments, the light guide is configured for arranging the first light source (providing the first light) in such cavity or tunnel.

At least part of the treatment cap, especially comprising the first face, may be transmissive for (at least part of) light emitted by the second light source. This may be true even if it the part may not be transmissive for light emitted by the first light source. For instance, a material of the treatment cap may (partly) block light having a small wavelength and allows light having a larger wavelength to pass. Said part may (also) comprise at least part of the illumination area. Especially, the first face comprises the part (of the treatment cap being transmissive for light emitted by the second light source).

In embodiments, at least part of the treatment cap is transmissive for (at least part of) light emitted by the second light source, especially for second light, especially wherein the part (of the cap) comprises at least part of the illumination area. By actuating the second light source, the second light may be provided at the wound. Hence the light (provided to the wound) may comprise second light.

Light downstream of the illumination area, preferably is applied for the treatment process in the treatment space. To contain the light in the treatment space, the treatment cap may further comprise a reflective region, especially arranged at the first face. The reflective region is especially configured for reflecting at least part of the light in the treatment space. The reflective region may e.g. comprise a coating comprising a metal selected from the group consisting of silver, aluminum, and gold. In further embodiments, the reflective region comprises a (reflective) polymer coating. In yet further embodiments, the coating or reflective area may comprise a diffuse reflective synthetic material, such as

comprising PTFE (Polytetrafluoroethylene), e.g. marketed by SphereOptics under the brand names Zenith Polymer and Spectralon, or marketed by Gigahertz-Optik GmbH under the name OMD98. The reflective region may in embodiments reflect only part of the light. In further embodiments, it may reflect substantially all of the light. The reflection may e.g.
5 depend upon a wavelength of the light.

The actuator (a further actuator) may comprise a fluid handling system. The fluid handling system may e.g. be configured for providing fluid in the treatment space, and/or removing fluid from the treatment space, e.g., by tubing. The fluid may, e.g., be used to flush the treatment space. The fluid may be applied to cleanse the wound. The fluid may
10 be used to remove debris from the treatment space and/or from the wound. The fluid may provide wound hydration. The fluid may directly and/or indirectly be provided to the treatment space. The fluid handling system may in embodiments, for example, be configured for providing the fluid to the fluid chamber. The fluid may successively travel (or diffuse) to the treatment space. Especially a gaseous fluid may travel from the fluid
15 chamber to the treatment space via a permeable wall of the fluid chamber (see further below).

The term “flushing” as in “flushing the treatment space”, “flushing the wound” and the like, may relate to “irrigation” of the wound.

To prevent harming granulation tissue, the fluid handling system may be
20 configured to provide the fluid in the treatment space at an over pressure selected from the range of 200-1000 mbar. In embodiments, the fluid handling system (including, or as well as, the tubing) is configured for recirculating the fluid. In further embodiments, the fluid handling system (and the tubing) is configured for removing fluid from the treatment space. For instance, the fluid handling system may be configured for removing exudate from the
25 wound. The fluid handling system is especially configured for removing an exudate (from the wound) from the treatment space (through the tubing). Removal of the exudate may also be called “instillation” or “negative pressure wound therapy. Hence, the fluid handling system may in embodiments be configured for installation.

The fluid handling system may further be configured to provide a reduced
30 pressure or vacuum in the treatment space. By providing a vacuum or reduced pressure (or negative pressure), the first face of the treatment cap and the wound may be drawn towards each other. As such, the first face may provide a protective cover on top of the wound, especially artificially providing a scab or a crust, and especially enhancing the treatment of the wound. In the method of the invention, the vacuum may be provided temporarily (and

repeatedly) to support the treatment process (during a compression period, see below). The fluid handling system (and the tubing) may be configured for providing a reduced pressure (a vacuum) to the treatment space, especially wherein the (reduced) pressure in the treatment space is selected from the range of 0.05-1 bar (absolute), such as 0.2-1 bar (absolute), especially from the range of 0.5-1 bar (absolute), even more especially from the range of 0.7-1 bar (absolute), like at maximum 0.98 bar (absolute), such as at maximum 0.95 bar (absolute). An absolute pressure of 1 bar in the treatment space, may relate to atmospheric conditions, especially to no reduced pressure. The value of 1 bar (absolute) may therefore be excluded from given ranges. In embodiments, the fluid handling system may be configured for providing an absolute pressure in the treatment space selected to be less than atmospheric pressure, especially less than 1 bar (absolute).

Yet, in embodiments, the pressure provided to the treatment space is selected from the range 0.9-1 bar. Especially a pressure that is only minimally less than atmospheric pressure may ensure that the treatment cap is forced in a direction to the skin (wherein the first face and the wound are still spaced apart) and that the treatment space may be securely sealed. Yet, the treatment cap may further be provided at the skin with further (external) elements to provide the sealed treatment space. By actuating the fluid handling system, a negative pressure may be provided in the treatment space. Yet, actuating the fluid handling system, may also comprise providing a fluid in the treatment space, especially a flushing fluid (see below), and/or extracting a fluid from the treatment space. Actuating the fluid system especially comprises providing a flow through the tubing. The fluid may be transported via tubing (connected to the fluid handling system).

Herein, the term “tubing” relates to any kind of a hollow object configured to hold and transport a fluid. Hence, the term may e.g. relate to piping, a fluid conduit, a tube, etc., either (at least partly) flexible or rigid. The term may thus also relate a hollow fiber, such as the hollow fiber of a light guide. In an embodiment, the tubing may comprise the light guide and/or any other hollow fiber. Essentially, the fluid handling system is configured in fluid contact with the treatment space (when in use). The fluid contact may in embodiments comprise a (gaseous) fluid contact via the fluid chamber, especially via the gas permeable wall/sheet.

The treatment system may, thus, comprise a fluid handling system and tubing, wherein the tubing is configured for providing a fluid connection between the treatment space and the fluid handling system. Especially, the fluid handling system (and the tubing) is configured for supplying a fluid flow through the tubing. Additionally or

alternatively, the fluid handling system (and the tubing) is configured for extracting a fluid from the treatment space (through the tubing). The fluid handling system may in embodiments be configured for providing the fluid to the fluid chamber. In embodiments, the tubing fluidly connects the fluid handling system to the fluid chamber. In further
5 embodiments, the fluid chamber is fluidly connected to the treatment space (especially via a permeable wall of the fluid chamber).

The fluid handling system does not require providing a continuous flow. In embodiments (of the method), e.g. a fluid flow may be provided to the treatment space at a first moment, whereas a fluid is extracted from the treatment space at another moment.
10 Moreover, in specific embodiments, a fluid may be provided to the treatment space, while at the same time a fluid is extracted from the treatment space.

In embodiments, the treatment arrangement, especially the treatment cap, comprises the fluid handling system and/or the tubing. The fluid handling system and/or the tubing may (detachable) be hosted by the treatment arrangement. Alternatively or
15 additionally, the fluid handling system and/or the tubing may (detachable) be hosted by the treatment cap.

In specific embodiments, the fluid handling system is configured for flushing the treatment space with a flushing fluid. The flushing fluid may be adapted to cleanse the wound (superficially). The flushing fluid may be adapted to sanitize the wound
20 (and/or the treatment space). The flushing fluid may comprise a liquid flushing fluid (i.e. "a flushing liquid"). The flushing fluid may (also) comprise a gaseous flushing fluid (i.e. "a flushing gas"). The flushing fluid especially comprises one or more flushing liquids selected from the group consisting of water, a saline solution, ozonated water (or ozonized water), oxygenated water, hydrogen-rich water (also known as hydrogen water), and an
25 aqueous hydrogen peroxide solution. Hence, in embodiments, the flushing liquid comprises water enriched with molecular hydrogen (gas) and/or oxygen and/or ozone. In embodiments, the hydrogen rich water comprises 0.1-1 mmol hydrogen per liter water, especially 0.25-0.8 mmol hydrogen per liter water. Hydrogen may especially ameliorate a reperfusion injury. Hydrogen (in a flushing liquid and/or a flushing gas) may especially be
30 used in the treatment of pressure ulcers. Hence, in an embodiment, the flushing fluid comprises hydrogen (gas).

In further embodiments, the oxygenated water comprises up to 30 mg oxygen dissolved per liter water, such as 10-30 mg oxygen / liter water, especially 15-20 mg oxygen per liter water. In further embodiments, the flushing fluid comprises a gaseous

flushing fluid, such as selected from the group consisting of ozone, oxygen, hydrogen, and nitrogen oxide. The term “flushing fluid” may thus also relate to a plurality of (different) flushing fluids.

In embodiments, the treatment system (further) comprises a liquid storage
5 container comprising the flushing liquid, especially wherein the liquid storage container is fluidly connected to the fluid handling system. In further embodiments, the treatment system (also) comprises a gas storage container comprising the gaseous flushing fluid, especially wherein the gas storage container is fluidly connected to the fluid handling system. Such embodiment may further advantageously be combined with embodiments,
10 wherein the tubing is configured for providing a fluid connection between the fluid chamber and the fluid handling system. The system may comprise a plurality of liquid and/or gas storage containers (for a plurality of flushing fluids). The treatment arrangement, especially the treatment cap may comprise the liquid storage container and/or the gas storage container. One or more of the liquid storage container(s) and the gas storage container(s)
15 may, e.g. (detachably), be hosted by the treatment arrangement, especially by the treatment cap.

Hence, in an embodiment the flushing fluid comprises a gaseous flushing fluid selected from the group consisting of ozone, oxygen, hydrogen, and nitrogen oxide (especially hydrogen), especially wherein the treatment system further comprises a gas
20 storage container comprising the gaseous flushing fluid and wherein the gas storage container is fluidly connected to the fluid handling system. In further embodiments, the tubing is configured for providing a fluid connection between the fluid handling system and the fluid chamber. Hence, in embodiments, the tubing (fluidly) connects the fluid handling system to the fluid chamber. In specific embodiments, the system may be
25 configured for providing the flushing fluid to the treatment space via the fluid chamber.

The flushing fluid may also (or additionally) be generated on the spot (when required). Hence, the treatment system may further comprise a flushing fluid generator, especially a gaseous flushing fluid generator, configured for generating the flushing fluid, especially the gaseous flushing fluid (i.e. a gas). In embodiments, the flushing fluid
30 generator is configured for generating a liquid flushing fluid, i.e. a flushing liquid. Herein, the term “flushing fluid generator” may relate to more than one (different) flushing fluid generator. In an embodiment, the treatment system comprises, e.g. a first flushing fluid generator configured for generating a first gaseous flushing fluid, a second flushing fluid

generator, configured for generating a second gaseous flushing fluid, and a third flushing fluid generator, configured for generating a flushing liquid.

In embodiments, the actuator (a further actuator) comprises a flushing fluid generator. The system may e.g. comprise a hydrogen generator and/or an oxygen generator, and/or and ozone generator, especially generating the gaseous flushing fluid from water and/or from air. Yet, the flushing fluid may further be generated from water, and/or air, and/or oxygen and/or ozone and/or hydrogen. The system may comprise a (flushing fluid) generator for providing one or more flushing liquid described above. In an embodiment, ozonated water is generated by bubbling ozone through water during a period of less than 60 minutes, such as during 10-30 minutes. Actuating the flushing fluid generator especially comprises generating the flushing fluid. In embodiments, the treatment arrangement, especially the treatment cap, comprises the (gaseous) flushing fluid generator. The (gaseous) flushing fluid generator may be (detachably) hosted by the treatment arrangement, especially by the treatment cap. The (gaseous) flushing fluid generator is especially fluidly connected to the fluid handling system.

The treatment cap may further be configured for (comprising or holding) the negative pressure (or positive pressure) in the treatment space (see also above) especially for (providing) a compressing contact between the first face and the wound, especially during the compression period. The system may be configured for providing a positive pressure to the wound. Hence, in embodiments, the treatment cap may be configured for a compression treatment of the wound. Compression of the wound may restore a vascular function. In embodiments, especially if the wound is related to a vascular problem, the method comprises compression (especially to restore vascular function). Compression may further provide mechanical stability to the damaged tissue. Mechanical stability may signal keratinocyte to migrate.

In embodiments, at least part of the treatment cap is flexible, and especially the first face of the treatment cap may be configured for contacting (at least part of) the wound during a compression period. It is noted that the term “contacting” is used in phrases like “contacting the damaged skin”, “contacting the wound”, although a biofilm (comprising e.g. exudate from the injury) may be present between the wound and the first face. Furthermore, contacting not necessarily relates to a full contact between the wound and the first face. In embodiments, only part of the wound is contacted. Moreover, for deep (subcutaneous) wounds, the treatment cap may not be able to contact the entire wound, or may only contact the skin over a closed wound. The skin tissue surrounding the wound may

not comprise such a biofilm. Hence, the term “contact” and the like in relation to the skin (surrounding the wound) may relate to a direct (physical) contact with the skin tissue. The treatment cap may especially be configured to cover the wound and a region surrounding the wound. Moreover, an area between one and three cm outside the perimeter of the wound may be metabolically very active. The treatment cap may in embodiments especially be configured to be arranged over an area that extends up to 5 cm, especially up to 3 cm, from the injured tissue. Hence, the treatment cap may be arranged over the wound and over a region surrounding the wound. Hence, the treatment system may especially be configured for treating the wound as well as the region surrounding the wound. Said region may in 5
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embodiments extend up to 5 cm, especially up to 3 cm, from (the perimeter of) the wound. In further embodiments, the treatment cap comprises a flexible skin contact rim protruding at the first face of the treatment cap, wherein the skin contact rim is configured for sealing the treatment space.

In use, the first face (of the treatment cap) and the wound may be drawn 15
towards each other by the negative pressure (provided by the fluid handling system). As such, the flexible skin contact rim may deform while keeping the sealing functionality. Additionally or alternatively, the first face may be pressed towards the wound by a force forcing the first face in a direction of the wound, either generated outside of the treatment cap or generated inside the treatment cap. The treatment cap may further be configured for 20
(temporarily and repeatedly) (during a compression period) providing a compressing contact between the first face and the wound. For this, the treatment cap may e.g. comprise a chamber that may be expanded (to provide the force). The chamber may e.g. be pressurized, such as by a pressurized liquid, to generate the force. In further embodiments, the pressure fluid comprises a gaseous fluid. The chamber is especially configured for 25
(temporarily) hosting a pressure fluid. By hosting the pressure fluid, the chamber, especially the treatment cap may expand, especially during the compression period. If a wall of the chamber comprises the first face, an expansion and/or pressurization of the chamber may force the wall (especially the first face) towards the wound, especially providing a mechanical pressure on the wound (during the compression period) (as also 30
may be configured if a negative pressure is provided in the treatment space). Hence, a wall of the fluid chamber may comprise the first face. The wall may be flexible, and especially may (substantially) be impermeable to liquid, preventing (the pressurized) liquid to pass through the wall. Yet, the wall may be permeable to gas (see further below). Hence, in an

embodiment, the wall of the fluid chamber comprises the first face, wherein the wall is substantially impermeable to liquid and permeable to gaseous compounds.

By moving the first face towards the wound (during the compression period), a volume of the treatment space will reduce. The treatment space may in
5 embodiments minimize, especially to a volume of substantially zero. During the
compression period, the volume of the treatment space may be reduced (relative to an initial
volume of the treatment space), such as especially to 1 cm³ or less, like 0.5 cm³ or less, like
0.05 cm³ or less, such as 0.005 cm³ or less or even like 0.0005 cm³ or less. During the
compression period, the volume of the treatment space may be reduced with at least 80%,
10 such as at least 90%, like at least 95%, or even at least 99%, or completely (i.e. 100%).
When releasing the pressure again, the first face may move again in a direction away from
the wound, and the volume of the treatment space may increase again, especially to at least
80%, such as at least 90% like at least 95%, or even at least 99%, or completely (i.e. 100%)
relative to the initial volume of the treatment space. The pressure may be increased by
15 providing the pressure fluid in the chamber. The pressure may be released again by
removing (at least part of) the pressure fluid from the chamber. The treatment cap may
expand by hosting the pressure fluid. The mechanical pressure may provide tactile
information for cells to grow and to heal the wound. Keratinocytes may e.g. be susceptible
to mechanical information. The mechanical pressure may further prevent a buildup of fluid
20 in the in the interstitium (located beneath the skin) and/or in cavities of the body of the
subject (providing swelling). Such build up is also known as edema and may cause severe
pain. The mechanical pressure may prevent edema.

Hence, in embodiments, the treatment cap comprises a (fluid) chamber for
(temporarily) hosting a pressure fluid for expanding the treatment cap during the
25 compression period, especially such that the first face contacts the wound. (Temporarily)
Hosting the pressure fluid / expanding (during the compression period) may provide the
(temporarily) compressing contact between the first face and the wound. The pressure fluid
may especially comprise a liquid. The pressure fluid may e.g. comprise a gel. The pressure
fluid may in further embodiments comprise a gaseous compression fluid. In specific
30 embodiments the pressure fluid and the flushing fluid are the same, especially gaseous,
fluid. The pressure fluid may in embodiments comprise one or more of the (gaseous)
flushing fluids described herein, for instance hydrogen. In an embodiment, the (fluid)
chamber may be pressurized (during a compression period) repeatedly with the pressure
fluid. The fluid may be provided and/or removed by hand to and/or from the chamber, e.g.

by means of a syringe. In embodiments, the treatment system further comprises a three-way valve. The three-way valve may be configured to fluidly connect the treatment space (directly or indirectly via the chamber) with any fluid supply system (of the fluid handling system) or with any fluid withdrawal system (of the fluid handling system). As such the treatment system may be configured for providing a fluid to the treatment space in a first configuration and for extracting a fluid from the treatment space in a second configuration. In further embodiments, the treatment system further comprises a pressure fluid control system configured to control expansion of the treatment cap. The pressure fluid control system may provide the pressure fluid in the fluid chamber during a compression period, and especially release the fluid from the chamber during other periods. The treatment system, especially the pressure fluid control system, may further comprise a pressure fluid container configured (in use) in fluid contact with the fluid chamber. The pressure fluid container is especially configured for containing at least part of the pressure fluid. In further embodiments, the pressure fluid control system may (also) be functionally be coupled to the fluid handling system, e.g. to control a flow of a gaseous flushing fluid to the fluid chamber. Hence, the actuator (a further actuator) may also comprise the pressure fluid control system. Actuating the pressure fluid control system may comprise pressurizing the chamber with the pressure fluid and/or releasing the pressure from the chamber (by removing the pressure fluid from the chamber).

In embodiments, the treatment arrangement, especially the treatment cap, comprises the pressure fluid container and/or the pressure fluid control system. The pressure fluid container and/or the pressure fluid control system may be (detachably) hosted by the treatment arrangement and/or the treatment cap.

To further allow for a flexibility and a (also) partly dimensional stability, the treatment arrangement may be reinforced with a frame. The frame may e.g. be (detachably) associated with the cap. The frame is especially associated to the treatment cap for provide a desired dimensional stability and/or integrity to (at least part of) the cap. The treatment cap may (detachably) comprise the frame. In further embodiments, the frame is coupled to the treatment cap for providing the dimensional stability. A part of the treatment cap may thus be flexible and resilient. A further part may be (may have become) rigid and/or stable as a result of the association with the frame. Hence, the treatment cap may further comprise a frame associated with the treatment cap and configured for reinforcing the treatment cap, especially thereby allowing the expansion and/or pressurization of the chamber.

In specific embodiments, the wall (of the chamber) is arranged between the second light source (e.g. arranged in the chamber) and the treatment space. Hence, the wall may comprise at least part of the illumination area. The chamber may further comprise or host one or more of the sensors. The sensor may be part of a sensor system (see below). For instance, the chamber may comprise a sensor for sensing a volatile compound (as an indicator for a status of the wound) in the treatment chamber. In specific embodiments, the wall (therefore) is permeable to gas. A permeable wall may further advantageously allow a gaseous pressure fluid to travel from the chamber to the treatment space. In further embodiments, the permeable wall may be selected having an oxygen transfer rate of at least 100 ml/m²/24 h, such as at least 1000 ml ml/m²/24 h. In further embodiments the wall may have a transfer rate of hydrogen, or e.g. carbon dioxide of at least 100, such as at least 1000, especially at least 10000 ml ml/m²/24 h. The sensor may alternatively or additionally be arranged in the treatment space.

The treatment system, especially the treatment arrangement, even more especially the treatment cap, may (thus) further comprise a sensor system, especially configured to determine a parameter of the treatment space and/or a status of the wound. The sensor system is especially configured for determining a parameter related to the treatment space and/or a parameter related to the status of the wound. By means of the sensor system, information about the wound may be obtained. The terms “status of the wound” may relate to a status of the healing process of the wound. The term and (also) a (respective) parameter of the treatment space may and/or a parameter related to the status of the wound, e.g. relate to a presence of a specific compound in the wound, in the treatment space and/or in the exudate from the wound. The term and the respective parameter may relate to a temperature of the wound, especially of the tissue of the wound. The term may further relate to a physical or chemical status of the wound. The term may relate to a dimensional status of the wound or of the treatment space, such as a depth of the wound, or e.g. a number of tunnel tracts in a tunnel wound, etc..

The sensor system may e.g. comprise a sensor for sensing a compound in treatment space, especially in the headspace of the treatment space, e.g. a presence and/or a concentration of the compound. Additionally or alternatively, the compound may be sensed in the exudate. Such compound may relate to the status of the wound and/or a status of a healing process of the wound. Examples of such compounds are (inorganic) salts (or the respective ions) such as sodium, potassium, chloride and/or urea, inorganic salts. The compound may comprise one or more of creatinine, glucose, growth factors, (proteolytic)

enzymes, lysozyme, protein(s) (plasma proteins, albumin, globulin, fibrinogen), an acid, especially lactic acid. The compound may (further) comprise one or more compounds selected from the group consisting of cytokines, macrophages, matrix metalloproteinases (MMPs), tissue inhibitors of metalloproteinases (TIMPs), (one or more types of)
5 microorganisms, neutrophils, white cells, platelets, fibrin, polymorphonuclearcytes (PMNs), debris, a dna and/or an rna rest, damage associated molecular patterns (molecules) (DAMPs), and pathogen associated molecular patterns (molecules) (PAMPs). The sensor is especially configured for sensing a compound described above.

In further embodiments, the sensor system may comprise a sensor
10 configured for sensing (a presence and/or concentration of) one or more of the flushing fluids provided to the treatment space. Hence, the sensor may be configured to check a parameter related to the effect induced by an actuator. Such information may e.g. be used to check or control the fluid handling system, especially via a control system functionally coupled to the sensor system and the fluid handling system (see further below). The
15 compound may thus, comprise ozone, oxygen, hydrogen, nitric oxide, or any other compound comprised in the flushing fluid. In further embodiments, the sensor system comprises a sensor for sensing a pressure in the treatment space, e.g. for checking the fluid handling system or the pressure fluid control system. A pressure sensor or a contact sensor may be used to assess a wound that extends into the body. The sensor may, e.g., be used to
20 assess a depth of a wound, or a number and/or a direction of tunnel tracts of a tunnel wound. A sensor may be arranged like embodiments of the first light source, at the tubing and/or any other fiber or tube, allowing the sensor to be moved (around) in the wound. Hence, in embodiments a further actuator comprises a sensor. Actuating the sensor may comprise moving the sensor. Furthermore, actuating a first light source may also comprise moving
25 the first light source.

The sensor system may further comprise a sensor configured for sensing a blood glucose concentration. The sensor system especially comprises one or more sensors for determining a volatile in the treatment space. The sensor especially comprises a sensor comprising a gas analyzer and/or an electronic nose. The sensor may in further
30 embodiments comprise a blood glucose sensor (analysis system), e.g. comprising a light emitting diode (providing near infrared light), a sensor and a spectrometer that may provide a non-invasive system for monitoring blood glucose levels, relevant for wound healing. Sensing the blood glucose level (in real-time) may be based on NIR (near infrared) techniques. Based on the sensed compound, the treatment cap may inform the subject

and/or e.g. a medical professional of a rapid glucose level change, or e.g. hyperglycemia. Wound healing may be impaired in diabetic patients with (chronic wounds) infection or hyperglycemia. Therefore, non-invasive glucose level measurements, and glycemic control may be most effective for treatment in diabetic wounds. The sensor system, especially the

5 sensor, may further comprise a pressure sensor, especially configured for sensing a pressure in the treatment space. Additionally, or alternatively, the sensor may comprise a sensor selected from the group consisting of a gas analyzer, an e-nose, a dielectric spectrometer, and a blood glucose sensor (or analysis system). The sensor may further sense electro-

10 magnetic radiation. The sensor may sense light, such as (near) infrared light, visible light, and/or UV light. Especially, the sensor may comprise (part of) a camera. In embodiments, the sensor further comprises a light sensor (or optical sensor). The light sensor may comprise a light spectrometer. A light sensor may sense (analyze) light reflected from the wound. The light sensor may sense the intensity (or amount) of light reflected by the wound. The light sensor may (also) sense the intensity (amount) of light emitted to the wound. A

15 light spectrometer may be configured to analyze a spectrum of the light being reflected by the wound. The light sensor may further be configured to analyze (sense) a spectrum of light emitted to the wound. The light spectrometer may especially be configured to determine the spectrum of light being absorbed by the wound (being the difference between the spectrum of light emitted to the wound and reflected by the wound). The light spectrum

20 may provide extra information about the wound compared to a visual observation (or a picture).

Hence, in embodiments one or more of the light sources of the (lighting) system may (also) be part of the sensor system. Such light source may e.g. comprise a flashlight. Such light source may be configured for emitting a broad spectrum, e.g. white

25 light.

A gas analyzer may be configured to sense a specific compound or a specific characteristic of a gaseous sample, especially in the treatment space. Additionally or alternatively, the gas analyzer may be configured to sense a presence of a plurality of compounds, and/or a concentration of the (plurality of) compound(s) (relative to the total

30 of the compounds) and/or a determined ratio between different compounds.

The gas analyzer may comprise a spectrometer. In a further embodiment, the sensor comprises a spectrometer, such as a dielectric spectrometer. The dielectric spectrometer may be connected to the treatment space by a hollow fiber comprising an inner wall comprising a dielectric material.

In a specific embodiment, the sensor system comprises the dielectric spectrometer, and the fluid conduit (and/or tubing) comprises a hollow fiber comprising (an inner wall, wherein the (inner) wall comprises) a dielectric material connectable to the dielectric spectrometer and configured for providing an electronic connection between the treatment space and the spectrometer, especially for sensing the (headspace) parameter of the treatment space. The fluid conduit may be part of the sensor (system). The fluid conduit may further be functionally connected to the gas supply and/or or fluid flushing system for allowing the fluid conduit to be cleaned and/or flushed.

Hence, the tubing may at least be part of the sensor. In further embodiments, the tubing comprises the sensor. In an embodiment, the tubing comprises a camera, especially for arranging in the treatment space. In further embodiments, a sensor may be arranged in a cavity of a tunnel wound (see further below).

The term “sensor” may also refer to a plurality of (different) sensors.

A sensor may sense different kinds of parameters described herein. Based on the sensed parameter, the sensor may provide a corresponding sensor signal directly or indirectly (e.g. via the sensor system), to a control system (see further below). In embodiments, the sensor may be configured to provide the sensor signal to the control system as a raw data signal. Alternatively, or additionally, the sensor signal comprises a pre-processed or fully processed data signal. Hence, the sensor may be configured to at least partially, such as fully, analyze or process the sensed parameter. Alternatively or additionally, the sensor system may be configured to at least partially, such as fully, analyze or process the sensed parameter.

Hence, in embodiments, the sensor system comprises a sensor, especially a sensor for sensing (i) a (headspace) parameter of the treatment space and/or for sensing (ii) a status of the wound. In embodiments, the sensor may be arranged in the treatment cap, e.g. in the chamber. Further, the sensor may be arranged in the treatment space (when the cap is arranged at the skin). In embodiments, at least part of the sensor system is (detachable) hosted by the treatment arrangement, especially by the treatment cap. The sensor may also be arranged external from the treatment cap and (only) being functionally coupled to the treatment space. In embodiments, the sensor is arranged external from the treatment arrangement. Hence, at least part of the sensor system may be arranged external from the treatment arrangement, especially external from the treatment cap. For that, the treatment system may further comprise a fluid conduit connecting the treatment space and the sensor. To prevent the fluid conduit from blocking, the fluid conduit may be flushed

and/or cleaned by a flushing fluid, especially by a gas supply, such as a gaseous flushing fluid.

In further embodiments, the fluid conduit (and/or tubing) is further connected to a gas supply for flushing the fluid conduit, especially for cleaning the fluid conduit. In specific embodiments, the treatment system comprises the fluid handling system and the tubing, the tubing comprises the fluid conduit, and the fluid handling system comprises the gas supply. Hence, the tubing may be functionally coupled to the treatment space, to the flushing system, and to the sensor.

The treatment system may further comprise a control system configured for controlling the treating of the skin tissue (in a control mode), especially based on (a) signal(s) of the sensor(s). Additionally or alternatively, the system may be configured for controlling the treating of the skin tissue based on a (time) schema or protocol and/or an external input. In a specific embodiment, the treatment system is configured to control (in a control mode) a controllable system comprising controllable elements, such as the actuator(s), especially to control the treating of the skin. Hence, the method may comprise controlling the treating of the skin tissue based on (a) signal(s) of the sensor(s) and/or based on a (time) schema or protocol and/or an external input.

The system, and/or arrangement, and/or cap may (be configured to) execute an action in a “mode” or “operation mode” or “mode of operation”. Likewise, in a method an action or stage, or step may be executed in a “mode” or “operation mode” or “mode of operation”. The term “mode” may also be indicated as “controlling mode”. This does not exclude that the system, or apparatus, or device may also be adapted for providing another controlling mode, or a plurality of other controlling modes. Likewise, this may not exclude that before executing the mode and/or after executing the mode one or more other modes may be executed.

However, in embodiments, a control system may be available, that is adapted to provide at least the controlling mode. Would other modes be available, the choice of such modes may especially be executed via a user interface, though other options, like executing a mode in dependence of a sensor signal or a (time) scheme, may also be possible. The operation mode may in embodiments also refer to a system, or apparatus, or device, that can only operate in a single operation mode (i.e. “on”, without further tunability).

The controllable system may, e.g., comprise one or more actuators as described herein. The actuator(s) may especially be selected from the of the group

consisting of the lighting system, the first light source, the second light source, the fluid handling system, the gas supply, the flushing fluid generator, and the pressure fluid control system. Especially, controlling of the controllable system may be based on control parameters, such as control parameters that relate to a signal of a sensor. Control may be based on (pre) determined treatment protocol (by an algorithm loaded in the control system). In further embodiments, control parameters may also relate to an input of a human, such as a medical professional or the subject (patient) having the treatment cap arranged at his wound. Moreover information from an anamnesis of the subject may be integrated in a treatment protocol

10 The human may base the input on the healing process of the wound, e.g. by means of one or more sensor signals. The human may also obtain information of the healing process by observing the wound. Therefore, the treatment cap may further comprise a (visible) light transmissive window for inspecting, especially from external of the treatment cap, the wound in the treatment space especially through the treatment cap. The window is essentially a light transmissive window. For that, the window may e.g. comprise a glass window, or a transparent polymer window. Yet, in further embodiments, the window comprises sapphire glass. Sapphire glass may provide a wear resistant window.

 The term “controlling” and similar terms herein especially refer at least to determining the behavior or supervising the running of an element, especially wherein the element is configured to adjust the treating of the damages skin tissue (such as an actuator). Hence, herein “controlling” and similar terms may e.g. refer to imposing behavior to the (controllable) element (determining the behavior or supervising the running of an element), etc., such as e.g. measuring, displaying, actuating, opening, shifting, changing temperature, etc., especially actuating. Beyond that, the term “controlling” and similar terms may additionally include monitoring. Hence, the term “controlling” and similar terms may include imposing behavior on an element and also imposing behavior on an element and monitoring the element. The controlling of the element can be done with the control system. The control system and the (controllable) element may thus at least temporarily, or permanently, functionally be coupled. The element may comprise at least part of the control system. In embodiments, the control system and element may not be physically coupled. Control can be done via wired and/or wireless control. The term “control system” may also refer to a plurality of different control systems, which especially are functionally coupled, and of which e.g. one control system may be a master control system and one or more others may be slave control systems.

Hence, in an embodiment, the treatment system further comprises a control system and a controllable system, wherein the control system is configured to control the controllable system, especially based on a determined treatment protocol. In embodiments of the treatment system (comprising the sensor system), the control system is configured to control the controllable system as a function of a signal of the (or at least one) sensor(s). The control system may further be configured to determine a status of a healing process of the wound based on the signal of the sensor. The control system may thus control the controllable system based on a status of the healing process of the wound. In further embodiments, the treatment system further comprises an input device, especially a user input device, functionally coupled to the control system, wherein the control system is further configured to control the controllable system based on a (human) interaction with the (user) input device.

In embodiments, the treatment arrangement, especially the treatment cap, comprises at least part of the control system and/or the controllable system. In embodiments, the control system is (detachable) hosted by the treatment arrangement, especially by the treatment cap.

The healing process of a wound tissue may be a complex process. The effects of different actuators on the healing process of the wound may e.g. be inter-correlated, may depend on the subject, and e.g. may depend on the status and or type of the damage of the skin tissue. In the art, many factors may be known that negatively affect the status of the wound, especially that may enlarge a size of the injury. Most medical practitioners know how to affect these factors, e.g., by removing a part of the injured skin, or by providing medication. Yet, not much is known about factors that positively affect the size of the injury. Moreover, the effect of these factors, such as the presence of specific enzymes and/or microorganisms at the wound, providing a mechanical stress to the injury, providing oxygen to the injury, etc. may depend on each other. Therefore, the control system may comprise a self-learning control system. A self-learning control system may be able to determine the effect of (controlled) actions of the controllable system, especially of the actuators, on (the healing process of) the wound, and may adapt (its) control algorithms based on the determined effects (and the expected effect).

Herein the terms “algorithm” as in “algorithms”, “control algorithms” “the treatment algorithms”, etc. may relate to the algorithm(s) for controlling the controllable system, the algorithms related to the control mode of the control system.

In a specific embodiment, the control system comprises a self-learning control system, configured to adapt controlling the controllable system based on (the healing process of) the wound. Furthermore, the control system may comprise a self-learning control system, especially configured for (self) improving (adapting) control algorithms based on the status (of the healing process) of the (damaged) skin tissue (the wound) and/or e.g. based on previous use or simultaneous use of a (further) treatment system.

The control system may comprise a stand-alone control system. Yet, in further embodiments, the control system may be functionally connected to a remote (control) system. Such remote system may comprise e.g. a smart phone, a smartwatch and/or an electronic health record (EHR). The remote system may further comprise a data acquisition unit and/or a data processor. The remote system may be functionally connected to control systems of further treatment systems and/or a database comprising information about the effect of a control algorithm on the healing process the wound. The remote system may comprise elements to display information about the status (of the healing process) of the wound, e.g. to the subject, a doctor, or a medical practitioner. The control system may further be configured to transmit clinically relevant data by the functional connection, especially allowing the doctor or medical practitioner to remotely follow the healing process and/or remotely inspect the wound and optionally to adjust the controlling of the controllable system by the control system. Hence, in embodiments, the control system controls the controllable system(s) based on a signal of one or more sensors and/or expert knowledge, e.g. provided by a medical professional and/or a remote system (see below). Therefore, in embodiments the control system may comprise or may be functionally coupled to a (wireless) communication device, such as for communication with the remote (control) system.

A connection between the remote system and the treatment system may be cabled. In embodiments, the connection is wireless. Hence, the treatment system may further comprise a wireless transmission device configured for connecting to a remote system, especially for mutually exchanging information about the status (of healing process) of the wound and about algorithms for controlling the controllable system, especially based on one or more sensor signals, even more especially, based on the sensed headspace parameter and/or the sensed pressure of the treatment space.

In further embodiments, the wireless transmission device may be configured for transmitting relevant data, especially on a regular base, to a display device, such as a

smart watch or a smart phone of the subject. This way, the subject may be informed about the status of the wound. This way, the subject may also be alerted for an action to be taken, such as for alerting a medical professional or for removing the treatment cap e.g. for manually cleaning the skin tissue.

5 In embodiments, the treatment arrangement, especially the treatment cap, comprises the wireless transmission device. In further embodiments, the wireless transmission device is (detachable) hosted by the treatment arrangement, especially by the treatment cap.

 Hence, the treatment system may be configured to control the controllable
10 system, especially one or more of the actuators, based on an input. The input may, e.g., be provided by one or more of the sensor(s) (as a sensor signal), a human, such as the subject or a medical practitioner, and the remote system. Moreover, the input of the human, especially the medical practitioner, may be provided directly, such as by an input device, or indirectly via the remote system. Controlling may be based on the status of the wound.
15 Furthermore, based on the input, and the control algorithms (loaded in the control system and/or adapted by the self-learning control system), the control system may control the controllable system. The control system and/or the remote system may monitor the status of the wound over an extended period. Hence, the term “status of the wound” may also relate to “(a status of) the healing process of the wound. Moreover, the control algorithms
20 may be adapted based on the healing process.

 The treatment system essentially comprises power consuming elements, such the actuators described herein, e.g., the lighting system, the first light source, the second light source, the fluid handling system, the gas supply, the flushing fluid generator, and the pressure fluid control system, and/or the sensor system, and/or the wireless
25 transmission device, that may require energy to operate. Preferably, the treatment system may function during a prolonged period, without the need to be continuously plugged in a power supply. Hence, preferably the treatment system comprises a device that may store energy and/or than may obtain energy (provided) by (or from) a wireless transmission, e.g. provided by radio waves and/or magnetic waves. Using such system, power-consuming
30 elements may be recharged when required. Hence, the treatment system may be configured for capturing energy (provided) by a (external) wireless (power) transmission. In embodiments, the system comprises an energy conversion device configured for capturing energy transmitted by an (external) wireless power transmission and especially for converting the energy into energy required by one or more power consuming elements

described above, especially one or more of the lighting system, the first light source, the second light source, the fluid handling system, the gas supply, the flushing fluid generator and the pressure fluid control system, and the wireless transmission device, especially allowing the system to operate based on the energy transmitted by the (external) wireless (power) transmission. The transmission may e.g. comprise electromagnetic waves and/or power. The energy conversion device is especially functionally coupled to one or more of the energy consuming elements.

In a further aspect, the invention provides the treatment arrangement as described herein. In an embodiment, the treatment arrangement comprises the treatment cap comprising a controllable system comprising one or more actuators as described above, especially the lighting system comprising the first light source and the second light source, the fluid handling system, especially configured to provide the fluid in the treatment space at an over pressure selected from the range of 200-1000 mbar, and especially (also) configured for providing a vacuum (a reduced pressure) in the treatment space, wherein the arrangement further comprises (ii) a plurality of sensors as described above, and a control unit especially loaded with an algorithm for controlling the controllable system, especially based on one or more sensor signals, even more especially, based on the sensed headspace parameter and/or the sensed pressure of the treatment space.

In yet a further aspect, the invention provides the treatment cap described herein. The treatment cap especially comprises a treatment cap for treating and/or inspecting a wound of a subject. The treatment cap especially comprises a first face configured for arranging the treatment cap over the wound and for contacting skin tissue surrounding the wound, thereby defining a treatment space between the wound and the treatment cap, wherein a side of the first face comprises an illumination area configured for providing light at the wound, wherein the treatment cap is configured for providing (during a compression period) a compressing contact between the first face and the wound. Additionally or alternatively, the treatment cap comprises the gas permeable wall, especially configured for allowing a transport of the flushing fluid from the chamber to the treatment space.

The treatment cap further, especially comprise or is functionally coupled to (i) a lighting system configured to generate the light, wherein the light comprises a first light and a second light, wherein the lighting system comprises a first light source configured for generating the first light and a second light source configured for generating the second light, especially having a spectral distribution different from the first light. The

first light may comprise a wavelength selected from the range of 100-280 nm, especially a plurality of wavelengths selected from the range of 100-280 nm, and the second light may comprise a wavelength selected from the range of 280-1100 nm, especially a plurality of wavelengths selected from the range of 280-1100 nm. In embodiments, the treatment cap
5 further comprises or is functionally coupled to (ii) a fluid handling system and tubing, wherein the tubing is configured for providing a fluid connection between the treatment space and the fluid handling system (and wherein the fluid handling system is configured for supplying a fluid flow through the tubing), wherein the fluid handling system is configured for flushing the treatment space with a flushing fluid and/or for removing an
10 exudate from the treatment space (through the tubing). Additionally or alternatively, the tubing is configured for providing a fluid connection between the fluid chamber and the fluid handling system. In further embodiments, the treatment cap further comprises or is functionally coupled to (iii) a sensor configured to determine a parameter of the treatment space and/or a status of the wound; and especially (iv) a control system configured for
15 controlling one or more controllable systems based on a signal of the sensors, especially wherein the one or more controllable systems comprise one or more of the lighting system, the first light source, the second light source, the fluid handling system.

In an embodiment, the treatment cap further comprises a fluid chamber for hosting a pressure fluid, thereby allowing expanding the treatment cap, especially during
20 the compression period, such that the first face contacts (at least part of) the wound, wherein a wall of the fluid chamber comprises the first face, wherein the wall is substantially impermeable to liquid, and wherein the wall comprises the illumination area. The wall is especially substantially impermeable to the pressure fluid, especially to the pressure liquid. In further embodiments the wall is permeable to a gaseous pressure fluid. The wall is further
25 especially transmissive for light emitted by the second light source. The treatment cap may further comprise, may functionally be coupled to, or is functionally couplable to a pressure fluid container configured in fluid contact with the fluid chamber, and a pressure fluid control system configured to control expansion of the treatment cap. The wall is especially arranged between the fluid chamber and the treatment space. The treatment cap may
30 comprise a layer with a cavity. The wall may especially be configured closing the cavity. As such, the wall may define the fluid chamber (in the layer)..

The system, the arrangement, and the cap described herein may advantageously be used for a treatment and/or an assessment (inspection) of a wound or a method for treating and/or assessing (inspecting) a wound.

In the method for treating and/or for inspection, especially, the treatment cap (of the treatment system) (as described herein) is arranged over the wound, wherein the first face contacts the skin tissue surrounding the wound. The treatment cap may be configured for arranging the cap at the skin. The treatment cap may comprise attachment means for arranging the treatment cap at the skin. The treatment cap may comprise straps for arranging the treatment cap over the wound. The treatment cap may also be provided at the skin using a bandage. The cap may be connected to the skin using connection mean known in the art, such as bandage, band aid, adhesive plasters etc. The connection means or attachment means may especially be selected or configured to keep the cap in place when the chamber is compressed. Especially, the controllable system is functionally coupled to the control system and a treatment algorithm is loaded in the control system. Especially, also the sensor system is functionally coupled to the control system. In a further stage, the method may comprise allowing the control system to control the controllable system based on a signal of one or more of the sensors (and the treatment algorithm). In a further embodiment, a medical practitioner may monitor the healing process via a remote system and may provide input to adapt the algorithms for controlling the controllable system or the medical practitioner may (directly) adapt the treatment algorithms.

For treating and/or inspecting an undermined wound having an opening to the outside (of the body) being smaller than the lesion itself, the treatment may comprise a treatment system which allows for treatment in the wound. The treatment system, especially the treatment arrangement, even more especially the treatment cap, may be configured for matching the biomechanical requirements of the involved tissue, whilst allowing for treatment and/or inspection. Elements of the treatment system that may contact the wound, may be soft and/or resilient. In embodiments, these elements are deformable allowing them to be directed to the wound, e.g. via a small opening in the skin.

For treating and/or inspecting a tunneling wound, the treatment system may comprise a plurality of treatment systems, especially a plurality of treatment caps. The tunneling wound may comprise a plurality of wound openings to the exterior of the wound (a plurality of skin breaches). Each of the plurality of treatment caps may be arranged over a respective wound opening (to the exterior of the wound). In embodiments, a part of the tubing may be arranged in the open wound. In such embodiment, especially the (internal) wound may be cleansed and/or flushed with oxygenated water and/or any other flushing fluid to heal the tunneling part of the wound. Furthermore, in such embodiments a sensor comprised by the tubing or a sensor functionally coupled to the tubing may be arranged in

the internal wound. In an embodiment, the tubing comprises a camera, and the status of (the healing process of) the wound, such as the tunnel wound, may be assessed using the camera. Furthermore, (also) the first light source may in embodiments directly or indirectly (via a light guide) be arranged in the internal wound. Hence, in an embodiment, the treatment system is configured inspection and/or for irrigation (flushing) and/or draining the cavity, especially in combination with a light treatment, of a tunnel wound. The treatment system may thus be configured for reducing a microbial load and for promoting granulation in a tunnel wound.

Especially, the treatment system, treatment arrangement, and the treatment cap of the invention are configured for applying a method of treatment of the invention, as further defined herein. Hence, in the method of the invention, the treatment system and/or one or more of the elements included in the system may be used.

The treatment cap, especially, at least partly comprises a polymer, or is made of a polymer. The polymer may e.g. comprise polyethylene, poly lactic acid, nylon, polyvinylidene fluoride or polyvinylidene difluoride (PVDF) or any other polymer described above such as the PFTE polymers. The polymer may be selected comprising mechanical properties matching the skin tissue. For instance, the polymer may be flexible and or resilient allowing the polymer to adapt to the skin. Furthermore, the treatment cap may be configured to match (the mechanical properties of) the skin. The treatment cap may e.g. comprise a flexible (polymer) skin contact rim. Therefore, at least part of the treatment cap may be produced by 3D printing. 3D printing may especially provide a cheap, but also personalized treatment cap. The (dimensions of the) treatment cap may especially be configured based on the wound that has to be treated and/or inspected. For instance, the 3D printing may be based on digital information of the wound, such as a (digital) photograph or other digital data. 3D printing may especially be used to 3D print a user specific designed part of a cap for arrangement over a wound.

Therefore, in a further aspect, the invention provides a method for producing a treatment cap (for treating and/or inspecting a wound) as described herein. The method for producing a treatment cap comprising 3D-printing of a first part of the treatment cap. The first part especially comprises a layer with a cavity, wherein the layer further may comprise a host position configured for receiving a second light source, especially for allowing the second light source to emit second light in the cavity. The host position may comprise a plurality of host positions. Additionally or alternatively, the host position may be configured for receiving a plurality of second light sources. In embodiments, the layer

further comprises tubing, especially configured for providing a fluid connection between the cavity and an element external from the cavity. The tubing may be 3D printed during printing the layer. The layer may in embodiments be printed over (around) the tubing. The first part of the treatment cap is especially printed from a polymer such as described above.

5 A flexible gas permeable sheet ("sheet") may be arranged in the cavity, especially whereby the cavity is closed and wherein a chamber is defined by the layer and the gas permeable sheet at a first side of the gas permeable sheet. In embodiments, the sheet may cover the chamber (such that a total volume of the chamber and a total volume of the cavity are substantially the same. In further embodiments, the sheet may be arranged in the
10 cavity, wherein the total volume of the chamber is smaller than the total volume of the cavity, and especially, a (flexible contact) rim is defined extending from a plane of the sheet, away from the remainder of the layer. A combination of the rim and the sheet may function as a treatment space at a second side, opposite to the first side, of the gas permeable sheet. In embodiments, a flexible (contact) rim may be 3D printed at an edge of the layer
15 (especially after arranging the sheet in the layer) defining a central opening at the second side of the sheet. In embodiments, the flexible rim comprises the tubing, especially configured for providing a fluid connection between the central opening and an element external from the cavity. The tubing may be 3D printed during printing the flexible rim. The flexible rim may in embodiments be printed over (around) the tubing.

20 A second light source may be arranged in the host position, especially wherein the second light source is configured for providing second light in the cavity at the first side of the gas permeable sheet. The sheet is especially selected to be transmissive to second light (as described herein), especially to light having a wavelength in the range of 280-1100 nm. The second light source may be selected for provide light comprising a
25 wavelength in the range of 280-1100 nm. Yet, the second light source may in embodiments be configured for providing light having different wavelength (see also above). Hence, in embodiments (in use) light of the second light may be emitted to the sheet, and (at least partly be) transmitted through the sheet, and especially second light, especially having a wavelength selected in the range of 280-1100 nm, may (again) be generated at the (second
30 side of) the sheet the sheet of the treatment cap.

In embodiments, a first light source is arranged to the cap for providing first light emanating from the first light source (at the second side of the permeable sheet) in a direction away from (the second side of) the gas permeable sheet, especially in a direction away from the layer.

In an embodiment, 3D printing is based on (digital) information of the wound. The method may therefore comprise sensing a wound and (undamaged) skin tissue surrounding the wound, prior to 3D printing the first part of the treatment cap. 3D printing of the first part of the treatment cap may (than) be based on the sensing. Sensing may
5 comprise imaging e.g. by taking a picture, especially a plurality of pictures defining a 3D picture and/or 3D digital image information. Sensing may further comprises determining a contour of a wound, e.g. using a pressure sensor. Sensing the wound especially relates to sensing the topical part of the wound, especially the skin breach. The method may further comprise 3D-printing of electro conductive fibers and functionally coupling a power source
10 to the light sources by the electro conductive fibers. In embodiments, 3D printing further comprises providing a frame in the layer configured for receiving the sheet. 3D printing of the first part of the treatment cap may comprise printing a flexible contact rim at the layer defining at least part of the cavity, and configured for sealing the treatment space at the wound.

15 In embodiments, one or more sockets for arranging further actuators and/or sensors may be provided during 3D printing of the first part. In further embodiments, further actuators and/or sensors (described herein) may be arranged at, or functionally coupled to, the treatment cap. The method may further comprise functionally coupling a control system to the treatment cap, especially to one or more of the actuators and one or
20 more of the sensors.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which corresponding
25 reference symbols indicate corresponding parts, and in which:

Figs. 1-2 schematically depict aspects of the treatment system of the invention;

Figs 3-4 schematically depict some further aspects of the treatment system;

Fig. 5 schematically depicts an aspect of tubing; and

30 Fig. 6 schematically depicts some further aspects of the invention.

The schematic drawings are not necessarily to scale.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Figs 1 and 2, schematically depict some aspects of the treatment system 1 of the invention for treating and/or inspecting a wound 5 of a subject. The treatment system 1 comprises a treatment arrangement 1000. The treatment arrangement 1000 comprises a treatment cap 100. In the figures, the first face 101 of the treatment cap 100 is arranging over the wound 5, wherein it 101 contacts skin tissue 2 surrounding the wound 5. As such, a treatment space 160 between the wound 5 and the treatment cap 100 is defined. In Fig. 1, this space 160 is clearly visible. In Fig. 2, this space 160 substantially zero and filled up by the (flexible) treatment cap 100 and therefore not visible.

The treatment arrangement 1000 further comprises at a side of the first face 101 an illumination area 110 configured for providing (the) light 11 at the wound 5. The illumination area 110, not necessarily is a continuous area, and may comprise a plurality of spatially different illumination areas 110 as is schematically indicated in the figures. The depicted treatment system 1000, further comprises a lighting system 10 that is configured to provide or generate the light 11. The light 11 is especially generated at (or emitted from) the illumination area 110 (and may travel to the wound 5). A wavelength of the light 11 may especially be selected from the range of 100-1100 nm.

In Figs 1 and 2, the treatment cap 100 is configured for providing a compressing contact between the first face 101 and the wound 5 during a compression period. In Fig. 1, a body 145 of the cap 100 is arranged at a distance from the wound 5, having the treatment space 160 between the body 145 and the wound 5. During a compression period, the body 145 is compressed against the wound 5 as is depicted in Fig. 2, wherein the treatment space 160 is minimized and not indicated. In embodiments, the treatment cap 100 comprises a fluid chamber 140 for hosting a pressure fluid 141, see Fig. 3. By providing the pressure fluid 141 in the chamber 140, the treatment cap 100 may expand, such that the first face 101 contacts the wound 5. As discussed above a biofilm may be present at the wound 5.

The lighting system 10 may comprise a light source, especially a first light source 120 and/or a second light source 130 configured to generate the light 11 from the illumination area 110. The first light source 120 and or the second light source 130 may therefore be functionally coupled to the illumination area 110. In Figs 1 and 2, the lighting system 10 comprises both a first light source 120 as well as a second light source 130, especially four first sources 120 and a plurality of different (see fig. 1) second light sources 130. The first light source 120 is configured for generating the first light 121. The first light

121 and the second light 131 may have a wavelength selected from the range of 100-280 nm, and from the range of 280-1100 nm, respectively. The second light source 130 is configured for generating the second light 131. The light 11 may comprise the first light 121 and the second light 131. Independently of each other, the first light 121 and the second
5 light 131 may be generated as one or more of a pulsed light, and a continuous light. The first light 121 and the second light 131, especially the second light 131, may further be generated as a polarized light, an unpolarized light, and a combination of polarized light and unpolarized light.

The first light source 120 may comprise an LED (Light Emitting Diode) 115.
10 The first light source especially comprises a (first) array (of a plurality) of LEDs 115. In such a way, the LEDs 115 may generate the first light source light 121 having a plurality of wavelengths. Likewise, the second light source 130 may comprise an LED 115 and/or a second array 116 (of a plurality) of LEDs.

In Fig. 1, light is emitted by the first light 120 and guided to the illumination
15 area 110, and successively emitted at the illumination area 110 as second light 121. Herein the term “the light generated” and the like such as “the first light generated” especially relates to light emitted at the illumination area, i.e. the light 11. Hence, light emitted by the first light source 120 and/or the second light source 130 not necessarily is the same as the first light 121 or the second light 131. Yet, in Fig. 1, the light emitted by the light guide 600
20 may be the same as the light emitted by the first light source 120. As is schematically depicted, the guide 600 functionally connects the first light source 120 to the illumination area 110. Such light guide 600 may e.g. comprise a glass fiber, a quartz fiber or a hollow fiber 620 comprising a reflective inner wall 621, see also Fig. 4. In that figure, the illumination area 110 also comprises a light guide tip 601 of the light guide 600 and the
25 surface of a first array of LEDs 115

In Fig. 3 some further aspect of the system 1, arrangement 1000, and cap 100 are schematically depicted. The system 1 comprises two fluid handling systems 500 and tubing 400, a sensor system 700 and a pressure fluid container 900.

The fluid handling system 500 may be configured for supplying a fluid flow
30 through the tubing 400. Therefore, the tubing 400 is arranged for providing a fluid connection between the treatment space 160 and the fluid handling system 500. In embodiments, the tubing 400 is (also) arranged for providing a fluid connection between the fluid handling system 500 and the fluid chamber 140, as is indicated by the dotted lines (see also Fig. 4). In such embodiment, the fluid 515 may especially comprise a gaseous

fluid which may enter the treatment space 400 via the permeable wall 190. Hence, in embodiment, the flushing fluid 515 may be provided to the treatments space 160 directly. In further embodiments, the fluid 515 (a gaseous flushing fluid 515) may be provided to the treatment space 160 indirectly via the gas permeable wall 190. In further embodiments, both options may be configured. When the fluid 515 is provided via the chamber 140 and the wall 190, the flushing fluid 515 may also function as a pressure fluid 141. The (gaseous) flushing fluid 515 may especially be provided to the wound to irrigate the wound. The flushing fluid not necessarily need to be withdrawn from the treatment space 160. The fluid handling system 500 may provide several functions, such as flushing the treatment space 160, removing exudate 6 from the space 160, and optionally also providing a vacuum to the treatment space 160. Yet, the fluid handling system 500 may further be used to clean tubing 400, such as a hollow fiber 620. The fluid handling system 500 is especially configured for one or more of (i) flushing the treatment space 160 with a flushing fluid 515, (ii) removing an exudate 6 from the treatment space 160 through the tubing 400, (iii) providing a negative pressure to the treatment space 160. By flushing the treatment space 160, the treatment space 160 and the wound 5 may be cleansed and/or microorganisms may be inactivated. Further, debris 9 may be removed.

The flushing fluid 515 may comprise a flushing liquid 515, such as water, a saline solution, ozonated water, oxygenated water, hydrogen-rich water, and an aqueous hydrogen peroxide solution. The flushing fluid 515 may further comprise a gaseous flushing fluid 515, such as ozone, oxygen, hydrogen. One or more of the flushing fluids 515 may be generated on the spot and/or stored in a flushing fluid container (such as a liquid storage container and/or a gas storage container) fluidly connected to the fluid handling system 500. One or more of the flushing fluids 515 may also be generated by a (gaseous or liquid) flushing fluid generator 511. The flushing fluid generator 511 is especially (also) fluidly connected to the fluid handling system 500.

The treatment system 1 of Fig. 3 also comprises the sensor system 700. The sensor system 700 is especially configured to determine one or more parameter of the treatment space 160 and/or a status of the wound 5. The sensor system 700 may comprise a plurality of (different) sensors 710, such as a sensor 710 for sensing a gaseous compound or a sensor 710 for sensing a pressure in the treatment space 160. The sensor 710 (or at least part of it) may be comprised in the treatment cap 100, for instance in the fluid chamber 140 as is depicted in Fig. 3. Further, in the embodiments, a sensor 710 such as the pressure sensor 750 is arranged in the treatment space 160. The sensor system 700 may comprise

other types of sensors 710, e.g., a gas analyzer 711, an e-nose, a dielectric spectrometer 713, or a blood glucose sensor / analysis system. Some sensors 710 such as a pressure sensor 750 may be configured movable in the treatment cap 100. With such sensor 710, for instance a tunnel wound may be assessed by sensing the surface of the wound all over the tunnel track. Likewise, the first light 121 may be provided by a movably configured light guide 600, allowing for providing the first light 121 in a wound extending in the body, such as a tunnel wound. Also, the first light 120 may be configured movably in the treatment space 160, allowing providing the first light 121 in a deep wound 5. Such movable arrangement is e.g. schematically depicted Fig. 4 by an embodiment of the first light source 120, wherein the first light 121 is provided by an LED 115 arranged at a fiber that may be moved in a tunnel wound 5 (the tunnel wound 5 is not shown).

The wall 190 of the fluid chamber 140 that comprises the first face 110 may be substantially impermeable to liquid but permeable to gaseous compounds. As such, a gaseous compound in the treatment space 160 may be sensed by a sensor 710 in the chamber 140. Moreover, this further enable using a gaseous fluid as flushing fluid 515 to flush the wound 5 and using the gaseous fluid as pressure fluid 141 to provide a compression. If the inflow of gaseous fluid 515, 141 is configured below the rate of permeation through the wall 190 a pressure in the fluid chamber 140 may be controlled. The wall 190 is schematically depicted in Fig. 3. The wall 190 in Fig. 3 comprises a part of the illumination area 110. The remainder of the illumination area 110 is arranged at a distance from the wall 190.

As discussed above, the treatment cap 100 may be configured such that the first face 110 may be compressed at the wound 5. For instance, a (pressure) fluid 141 may be injected into (provided to) the fluid chamber 140 to expand the treatment cap 100, especially chamber 140 (also compare Fig. 2 to Fig. 1). The embodiment of Fig. 3 comprises a pressure fluid container 900 and a pressure fluid control system 910. The pressure fluid container 900 is configured in fluid contact with the fluid chamber 140. The pressure fluid control system 910 is configured to control expansion of the treatment cap 100, and may periodically provide an expansion of the treatment cap 100 (reducing a volume of the treatment space 160, and providing a contact between the wound 5 and the first face 101) and a relaxation of the treatment cap 100 (increasing the volume the treatment space 160). In embodiments, the treatment system 1 further comprises a frame 180 connected to treatment cap 100 configured for reinforcing the treatment cap 100, see

Fig. 4. A reinforced treatment cap 100 may e.g. ensure that an expansion of the treatment cap 100 provides the compression force acting on the wound 5.

Fig. 3 also schematically depicts that several functions may be combined by the tubing 400. At the left-hand side of the figure, the tubing 400 comprises a fluid conduit 5 410 comprising a hollow fiber 620, and providing a fluid connection between the treatment space 160 and one or more sensors 710 of the sensor system 700. In the embodiment, a gas analyzer 711 and a dielectric spectrometer 713. The hollow fiber 620 comprises a dielectric material 630, functionally coupling the dielectric spectrometer 713 and the treatment space 160. The hollow fiber 620 also comprises a reflective coating at the inner wall 621, and as 10 such may guide light emitted by the first light source 120, and therewith generating first light 121 in the treatment space 160. Moreover, in the embodiment, the hollow fiber 620 is further connected to a fluid handling system 500, especially a gas supply 510. This way a flushing fluid 515 as a gas from the gas supply 510 can be directed through the hollow fiber 610 to remove any blockage or obstruction that may prevent light or gasses to pass. 15 Furthermore, two reflective regions 150 of the treatment cap 100 are depicted at the first face 101. These reflective regions 150 can reflect light 11 back in the treatment space 160. For clarity reasons these reflections are not depicted.

The treatment cap 100 is especially flexible, allowing providing a treatment space 160 having a maximum volume, and allowing providing a compression at the wound 20 5 by minimizing the volume of the treatment space 160. The flexibility may further be increased by the flexible contact rim 191 that is configured for sealing the treatment space 160. In Fig. 3, the treatment cap 100 comprises the flexible skin contact rim 191 protruding at the first face 101 of the treatment cap 100.

In Fig. 3, further the term “at a side of the first face” is schematically 25 depicted. As discussed above, at least a part of the illumination area 110 may (directly) be arranged at the first face 101, whereas a part may also be arranged at a side of the first face. In the figure, light generated by the second light sources 130, travels from the chamber 140 through the wall 190 comprising the first face 101 and is successively emitted as second light 131 from the first face 101. As such, the illumination area 110 comprises the locations 30 of the first face 101 at which the second light 131 is emitted from. These locations are all arranged at the first face 101. Yet, the light emitted from the first light sources 120 are emitted in the treatment space 160 directly by the (array of) LED's 115 or via the light guide 600. The locations at which light emitted by the first light source 120 is provided as first light source 121 in the treatment space 160 are also part of the illumination area 110.

These latter locations are arranged at a distance from the first face 101. Hence, the term “at a side” in “at a side of the first face” comprises the first face 101 as well as locations arranged at a distance from the first face projecting from the first face 101, see also Fig. 4 wherein the first array of LEDs 115 arranged at the fiber also comprises part of the illumination area 110.

The embodiment of Fig. 3 further comprises a visible light transmissive window 170, such as a window comprising sapphire glass, for inspecting the wound 5 in the treatment space 160. Hence, even if the cap 100 is sealingly connected to the skin 2, this may allow the subject or a medical practitioner to inspect the status of the wound.

Fig. 4 schematically depicts some further aspect of the treatment system 1. The treatment system 1 comprises a control system 2000 and one or more controllable systems 2500. The controllable system 2500 may comprise one or more of the actuators described herein. The controllable systems 2500 depicted in Fig. 4 comprises at least part of the lighting system 10 (not indicated as such), especially a first light source 120 and a second light source 130, a fluid handling system 500, and a flushing fluid generator 511, for generating a gaseous or a liquid flushing fluid 515 (the liquid flushing fluid 515 is herein also referred to a flushing liquid). The embodiment depicted in Fig. 4, further comprises a liquid storage container 512 and a gas storage container 513, both fluidly connected to the fluid handling system 500. Additionally or alternatively, the controllable system 2500 may also comprise a pressure fluid control system 910.

The control system 2000 is configured to control the controllable systems 2500, as is indicated by the dotted lines. The depicted system 1 further comprises the sensor system 700, comprising a pressure sensor 750 and a further sensor 710. The control system 2000 is especially configured to control the controllable systems 2500 (in a control mode) as function of a signal of one or more of the (pressure) sensor(s) 710, 750. The control system 2500 may further be configured to control the controllable systems 2500 based on a human interaction with an input device 2001. In the embodiment, the input device 2001 is functionally coupled to the control system 2000. The control system 2000 may further be configured to determine a status of a healing process of the wound 5 based on the signal of the sensors 710, especially based on the signals over an extended period. The control system 2000 may be configured to adapt the (treatment algorithms for) controlling the controllable system 2500 based on the healing process of the wound 5. In embodiments, the control system 2000 comprises a self-learning control system 2000.

As discussed above, the treatment cap 100 may be produced by 3D-printing. Aspects of this method are depicted by means of Fig. 3. In the method, a first part of the treatment cap 100 is 3D printed. The first part comprises a layer 146 with a cavity 192. The layer further comprises one or more host positions 135 configured for receiving a second
5 light source 130, such that the second light source 130 may emit second light 131 in the cavity 192. The layer 146 may further comprises tubing 400 configured for providing a fluid connection between the cavity 192 and an element external from the cavity 192.

A flexible gas permeable sheet 190 is arranged in the cavity 192, closing the cavity 192. As such, the chamber 140 is defined by the layer 146 and the gas permeable
10 sheet 190 at a first side of the gas permeable sheet 190. The gas permeable sheet especially defines the wall 190 of the chamber 140. The sheet 190 may completely cover the cavity 192. As such the cavity now function as the chamber 140. Especially in such embodiment, a flexible rim 191 is successively (also) 3D printed at the layer 146, and the flexible rim 192 comprises the tubing 400. The embodiment given in Fig 3 may be produced this way.
15 Hence, in Fig. 3 the reference 192 pointing to the cavity especially refers to the chamber 140.

The sheet 190 may also be arranged in the cavity 192 to define the chamber 140 at the first side of the gas permeable sheet 190, and a further cavity or central opening 160 at a second side, opposite to the first side, of the gas permeable sheet 190, that may
20 function as the treatment space 160. Hence, in embodiments, the reference 192 may refer to a combination of the chamber 140 and the treatment space 160 (although during production represented by the central opening 160 (that may function as a treatment space 160)).

Further, a second light source 130 is arranged in the host position 135,
25 wherein the second light source 130 is configured for providing second light 131 in the cavity 192, especially in the chamber 140 that is formed, at the first side of the gas permeable sheet 190. A first light source 120 may be arranged to the cap 100 for providing first light 121 emanating from the first light source 120 in a direction away from the gas permeable sheet 190.

30 Fig. 4 further schematically depicts a wireless transmission device 3000 comprised by the system 1, and functionally coupled to the control system 2000. The wireless transmission device 3000 is configured for connecting to the remote system 4000. This way, the two systems 2000, 4000 may (mutually) exchange information about the status of healing process of the wound 5. For instance allowing a remote system 4000 to

analyze the data, or for presenting the data to a medical practitioner. Based on an analysis of the data, an adapted treatment protocol may be advised by the remote system and/or medical practitioner, and especially may be sent back to the control system 2000. Hence, the transmission device 3000 may further be configured for connecting to the remote
5 system 4000 for (mutually) exchange information about algorithms for controlling the controllable system 2500 based on the signal of the sensor and/or based on the status of the healing process.

The (external) wireless (power) transmission signal should not be confused with another wireless signal described herein. The (external) wireless power transmission
10 may be used to provide energy to the treatment system 1 (not depicted in the figures). Power may e.g. be transmitted via magnetic energy. Embodiments of the treatment system 1 may comprise an energy conversion device (not shown), for converting energy transmitted by an external wireless (power) transmission into energy required by an energy-consuming element. The system 100 may then be operated based on the energy transmitted by the
15 (external) wireless (power) transmission.

Fig. 5 schematically depicts a hollow fiber 620, which may be part of the tubing 400 and may be used as a light guide 600 (see Fig. 3). The hollow fiber 620 comprises a dielectric material 630, as well as a reflective coating 622 at the inner wall 621.

In Fig. 6 some further aspects of an embodiment of the treatment cap 100
20 are depicted. In the figure the different regions of the wound 5 having different types of tissue are depicted. An open wound (bed) may roughly be described as having four types of tissue (cells). In the first region 5a the cells may especially be damaged. In a second region 5b surrounding the damaged cells, the cells may be injured. In a third region 5c, the cells may (only) be stressed. In a fourth region 5d, the cells may (only) still be adapted. For
25 clarity reasons these regions are depicted as discrete regions. Yet, the cells in these regions may gradually change from damaged to injured to stressed and successively to adapted (and finally to normal). Because the treatment with actuators, such as the lighting system 10, may affect the cells in the different regions 5a, 5b, 5c, 5d differently, the treatment system 1000, especially the treatment cap 100 may in embodiments be configured for providing a
30 different treatment to the different types of cells.

The lighting system 10 of the treatment cap 100 in Fig. 6, e.g. comprises three sets 13, 14, 15 of second light sources 130 (in the depicted embodiment referred to as second light sources 130, however, in other embodiments these light sources may be first light sources 120). The sets 13, 14, 15 of (second) light sources 130 are arranged

corresponding to the contours of the wound 5 (in the fluid chamber 140). For a circular wound 5, the sets 13, 14, 15 may thus be arranged in a circular fashion (around the center of the treatment cap 100). The first set 13 of the plurality of (second) light sources 130 (120) is arranged closed to the center of the treatment cap 100. The second set 14 of a plurality of second light sources 130 is arranged surrounding the first set 13, and the third set 15 is arranged further remote from the first set 13.

The sets 13, 14, 15 of second light sources 130 may especially comprise LEDs 115. The sets 13, 14, 15 may further especially be configured for emitting second light 131 (or first light 121 in case of first light sources 120) with different wavelengths. For instance the first set 13 may generate second light 131 having a wavelength from 600-1100nm. The second set 14 may generate second light 131 having a wavelength 500-600 nm. The third set 15 may generate second light 131 having a wavelength from 28-500 nm. Because the penetration depth of the lights 11 with different wavelengths and because of the spatial arrangement of the second light sources 131, light 11 from the first set 13 of second light sources 130 may especially affect (or treat) the stressed cells in the third region 5c, the injured cells in the second region 5b, and the damaged cells in the first region 5a, and optionally the adapted cells in the fourth region 5d. Light 11 from the second set 14 may especially affect the injured cells in the second region 5b, and optionally the damaged cells in the first region 5a. And light 11 from the third set 15 may especially affect the damaged cells in the first region 5a.

The depicted embodiment further comprises a flashlight 12 arranged near the center of the treatment cap 100. The flashlight 12 may generate pulsed light. The flashlight 12 may be configured to generate light having a wavelength from 100-1100 nm. The flashlight 12 may in further embodiments generate (the wavelengths of) white light. High intensity flashed light, especially over a broad range of wavelength as described herein may active/start some biochemical processes in the cells that may less effectively be activated by continuous light.

Furthermore, in Fig. 6 a light (or optical) sensor 710, 715 especially a light spectrometer 715 is arranged in the center of the treatment cap 100. The light spectrometer 715 may be used to determine the status of the wound 5 based on the light that is reflected by the wound 5. In embodiments of the method, white light may be generated with the flashlight 12, wherein the reflected is analyzed with the light spectrometer 715. It is note that embodiments of the treatment cap 100 comprising the sets 13, 14, 15 of (second or

first) light sources 13, 120 arranged around the center of the treatment cap 100 may also be configured without the light sensor 715

Hence, in an embodiment, during use, the treatment cap 100 comprises a permeable film 160 covering the wound bed 5. The treatment cap 100 is placed and sealed by means of a flexible ring 191 covering the wound 5 and the surrounding area. The treatment cap 100 in embodiments comprises a flashlight producing element 12 which illuminates the area under the cap 100. In embodiments (of the method for treating a wound) an optical sensor 715 may be applied to analyse the reflected light to determine if the wound bed 5 is suitable for the application of light 10. Once the wound bed 5 has been approved, the 100 provide its sequence of wavelengths, pulses, intensity and duration as controlled by the control system 2000.

In specific embodiments, the permeable film 160 may be configured detachably from the treatment cap 100, such that after use (after the treatment), the permeable film 160 may remain on the wound 5 to protect the underlying tissue and prevent further damage and/or contamination.

The terms “substantially” and “essentially” herein, such as in “substantially all light” or in “substantially consists”, will be understood by the person skilled in the art. The terms “substantially” and “essentially” may also include embodiments with “entirely”, “completely”, “all”, etc. Hence, in embodiments the adjectives substantially and essentially may also be removed. Where applicable, the terms “substantially” and “essentially” may also relate to 90% or higher, such as 95% or higher, especially 99% or higher, even more especially 99.5% or higher, including 100%. The term “comprise” includes also embodiments wherein the term “comprises” means “consists of”. The term “and/or” especially relates to one or more of the items mentioned before and after “and/or”. For instance, a phrase “item 1 and/or item 2” and similar phrases may relate to one or more of item 1 and item 2. The term “comprising” may in an embodiment refer to “consisting of” but may in another embodiment also refer to “containing at least the defined species and optionally one or more other species”.

Furthermore, the terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

The devices herein are amongst others described during operation. As will be clear to the person skilled in the art, the invention is not limited to methods of operation or devices in operation.

5 The terms “upstream” and “downstream” relate to an arrangement of items or features relative to the propagation of the light from a light generating means (here especially the light source), wherein relative to a first position within a beam of light from the light generating means, a second position in the beam of light closer to the light generating means is “upstream”, and a third position within the beam of light further away from the light generating means is “downstream”.

10 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 "to comprise" and its conjugations does not exclude the presence
15 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, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere
20 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.

The invention further applies to a device comprising one or more of the characterizing features described in the description and/or shown in the attached drawings. The invention further pertains to a method or process comprising one or more of the
25 characterizing features described in the description and/or shown in the attached drawings.

The various aspects discussed in this patent can be combined in order to provide additional advantages. Further, the person skilled in the art will understand that embodiments can be combined, and that also more than two embodiments can be combined. Furthermore, some of the features can form the basis for one or more divisional
30 applications.

CLAIMS:

1. A treatment system (1) for treating a wound (5) of a subject, wherein the
5 treatment system (1) comprises a treatment arrangement (1000), wherein the treatment
arrangement (1000) comprises a treatment cap (100) comprising a first face (101)
configured for arranging over the wound (5) and for contacting skin tissue (2) surrounding
the wound (5) thereby defining a treatment space (160) between the wound (5) and the
10 treatment cap (100), wherein the treatment arrangement (1000) further comprises at a side
of the first face (101) an illumination area (110) configured for providing light (11) at the
wound (5); wherein the treatment system further comprises a lighting system (10), optically
coupled with the illumination area (110), configured to generate the light (11), wherein the
light (11) has a wavelength selected from the range of 100-1100 nm; wherein the treatment
15 cap (100) is further configured for providing during a compression period a compressing
contact between the first face (101) and the wound (5); wherein the treatment cap (100)
further comprises a fluid chamber (140) for hosting a pressure fluid (141) for expanding
the treatment cap (100) during the compression period such that the first face (101) contacts
the wound (5) for the compressing contact between the first face (101) and the wound (5),
wherein a wall (190) of the fluid chamber (140) comprises the first face (101), and wherein
20 the wall (190) is substantially impermeable to liquid and permeable to gaseous compounds.

2. The treatment system (1) according to claim 1, wherein the lighting system
(10) comprises a first light source (120) configured to generate first light (121) having a
wavelength selected from the range of 100-280 nm; wherein the lighting system (10) further
25 comprises a second light source (130) configured to generate second light (131), having a
spectral distribution different from the first light (121), the second light (131) having a
wavelength selected from the range of 280-1100 nm, wherein the light (11) comprises the
first light (121) and the second light (131).

30 3. The treatment system (1) according to claim 2, further comprising a light
guide (600), wherein the light guide (600) is configured to functionally connect the first
light source (120) to the illumination area (110), wherein the light guide (600) comprises a
light guide selected from the group consisting of a glass fiber, a quartz fiber, and a hollow

fiber (620) comprising a reflective inner wall (621), and wherein the illumination area (110) comprises a light guide tip (601) of the light guide (600).

4. The treatment system (1) according to any one of the preceding claims 2-3,
5 wherein the first light source (120) is configured for generating the first light (121) as one or more of a pulsed light and a continuous light, and/or wherein the second light source (130) is configured for generating the second light (131) as one or more of a pulsed light, a continuous light, a polarized light, and a combination of polarized light and unpolarized light, wherein (i) the first light source (120) comprises a first array of Light Emitting Diodes
10 (LEDs) (115), wherein the first array of LEDs (115) is configured for generating the first light (121) having a plurality of wavelengths selected from the range of 100-280 nm, and/or wherein (ii) the second light source (130) comprises a second array (116) of Light Emitting Diodes (LEDs) (115), wherein the second array (116) of LEDs (115) is configured for generating the second light (131) having a plurality of wavelengths selected from the range
15 of 280-1100 nm.

5. The treatment system (1) according to any one of the preceding claims, further comprising a fluid handling system (500) and tubing (400), wherein the tubing (400) is configured for providing a fluid connection between the treatment space (160) and the
20 fluid handling system (500), wherein the fluid handling system (500) is configured for flushing the treatment space (160) with a flushing fluid (515); wherein one of:

- the flushing fluid (515) comprises one or more flushing liquids selected from the group consisting of water, a saline solution, ozonated water, oxygenated water, hydrogen-rich water, and an aqueous hydrogen peroxide solution, and wherein the
25 treatment system further comprises a liquid storage container (512) comprising the flushing liquid, wherein the liquid storage container (512) is fluidly connected to the fluid handling system (500);

- the flushing fluid (515) comprises a gaseous flushing fluid selected from the group consisting of ozone, oxygen, hydrogen, and nitrogen oxide; wherein the treatment
30 system (1) further comprises a gas storage container (513) comprising the gaseous flushing fluid, wherein the gas storage container is (513) fluidly connected to the fluid handling system (500); and

- the treatment system (1) further comprises a flushing fluid generator (511) configured for generating the flushing fluid (515), wherein the flushing fluid generator (511) is fluidly connected to the fluid handling system (500).

5 6. The treatment system (1) according to claim 5, wherein the flushing fluid (515) comprises the gaseous flushing fluid selected from the group consisting of ozone, oxygen, hydrogen, and nitrogen oxide, wherein the tubing (400) is configured for providing a fluid connection between the fluid handling system (500) and the fluid chamber (140).

10 7. The treatment system (1) according to any one of the preceding claims, further comprising a pressure fluid container (900) configured in fluid contact with the fluid chamber (140) and configured for containing at least part of the pressure fluid (141), wherein the treatment system (1) further comprises a pressure fluid control system (910) configured to control expansion of the treatment cap (100).

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8. The treatment system (1) according to any one of the preceding claims, further comprising a sensor system (700) configured to determine a parameter of the treatment space (160) and/or a status of the wound, wherein the sensor system (700) comprises a sensor (710) selected from the group consisting of a gas analyzer (711), an e-
20 nose (712), a dielectric spectrometer (713), a light spectrometer (715), a blood glucose sensor, and a pressure sensor (750), wherein the treatment system comprises one or more of (i) the first light source (120) and the second light source (130) defined in claim 2, (ii) the fluid handling system (500) defined in claim 5, (iii) the flushing fluid generator (511) defined in claim 5, and (iv) the pressure fluid control system (910) defined in claim 6,
25 wherein the treatment system (1) further comprises a control system (2000) and one or more controllable systems (2500), wherein the control system (2000) is configured to control the one or more controllable systems (2500), wherein the one or more controllable system (2500) are selected from the group consisting of the lighting system (10), the first light source (120) and/or the second light source (130), the fluid handling system (500), the
30 flushing fluid generator (511), and the pressure fluid control system (910), wherein the control system (2000) is configured to control the one or more controllable systems (2500) as function of a signal of the sensor (710), wherein the control system (2000) is further configured to determine a status of a healing process of the wound (5) based on the signal of the sensor (710), wherein the treatment system (1) further comprises an input device

(2001) functionally coupled to the control system (2000), and wherein the control system (2000) is further configured to control the one or more controllable systems (2500) based on a human interaction with the input device (2001).

5 9. The treatment system (1) according to claim 8, wherein the control system (2000) comprises a self-learning control system, configured to adapt controlling the one or more controllable systems (2500) based on the healing process of the wound (5).

10 10. The treatment system (1) according to any of the preceding claims 8-9, further comprising a wireless transmission device (3000) configured for connecting to a remote system (4000) for mutually exchanging information about the status of healing process of the wound (5) and about algorithms for controlling the controllable system (2500) based on the signal of the sensor (710).

15 11. The treatment system (1) according to any one of the preceding claims, wherein the treatment system (1) comprises an energy conversion device configured for converting energy transmitted by an external wireless power transmission into energy required by one or more of the lighting system (10), the first light source (120) and/or the second light source (130) according to claim 2, the fluid handling system (500) according to claim 5, the flushing fluid generator (511) according to claim 6, the pressure fluid control system (910) according to claim 6, and the wireless transmission device (3000) according to claim 9, thereby allowing the treatment system (1) to operate based on the energy transmitted by the external wireless power transmission.

25 12. The treatment system (1) according to any one of the preceding claims, wherein the treatment cap (100) comprises a reflective region (150) at the first face (101), wherein the reflective region (150) is configured for reflecting at least part of the light (11) in the treatment space (160).

30 13. The treatment system (1) according to any of the preceding claims, wherein the treatment cap (100) comprises a flexible skin contact rim (191) protruding at the first face (101) of the treatment cap (100), wherein the skin contact rim (191) is configured for sealing the treatment space (160).

14. The treatment system (1) according to any of the preceding claims, wherein the treatment cap (100) further comprises a visible light transmissive window (170) for inspecting from external of the treatment cap (100) the wound (5) in the treatment space (160), especially wherein the window (170) comprises sapphire glass.

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15. A treatment cap (100) for treating a wound (5) of a subject, wherein the treatment cap (100) comprises a first face (101) configured for arranging the treatment cap (100) over the wound (5) and for contacting skin tissue (2) surrounding the wound (5) thereby defining a treatment space (160) between the wound (5) and the treatment cap (100), wherein the first face (101) comprises an illumination area (110) configured for providing light (11) at the wound (5), wherein the treatment cap (100) is configured for providing during a compression period a compressing contact between the first face (101) and the wound (5), wherein the treatment cap (100) further comprises a fluid chamber (140) for hosting a pressure fluid (141) thereby allowing expanding the treatment cap (100) such that the first face (101) contacts the wound (5), wherein a wall (190) of the fluid chamber (140) comprises the first face (101), and wherein the wall (190) is substantially impermeable to liquid and permeable to gaseous compounds, wherein the treatment cap (100) further comprises a lighting system (10), optically coupled with the illumination area (110), configured to generate the light (11), wherein the light (11) has a wavelength selected from the range of 100-1100 nm

16. The treatment cap according to claim 15, wherein the light (11) comprises a first light (121) and a second light (131), wherein the lighting system (10) comprises a first light source (120) configured for generating the first light (121) and a second light source (130) configured to generate the second light (131), having a spectral distribution different from the first light (121), wherein the first light (121) comprises a wavelength selected from the range of 100-280 nm, and the second light (131) comprises a wavelength selected from the range of 280-1100 nm; wherein the treatment cap further comprises:

- a fluid handling system (500) and tubing (400), wherein the tubing (400) is configured for providing a fluid connection between the treatment space (160) and the fluid handling system (500), and wherein the fluid handling system (500) is configured for supplying a fluid flow through the tubing (400), wherein the fluid handling system (500) is configured for flushing the treatment space (160) with a flushing fluid (515) and for removing an exudate (6) from the treatment space (160);

30

- a sensor (710) configured to determine a parameter of the treatment space (160) and/or a status of the wound (5);
- a control system (2000) configured for controlling one or more controllable systems (2500), based on a signal of the sensor (710), wherein the one or more controllable systems (2500) comprises one or more of the lighting system (10), the first light source (120), the second light source (130), and the fluid handling system (500).

17. The treatment cap (100) according to claim 16, wherein the treatment cap (100) further comprises or is functionally coupled to:

- a pressure fluid container (900) configured in fluid contact with the fluid chamber (140), and a pressure fluid control system (910) configured to control expansion of the treatment cap (100) during the compression period.

18. Use of the treatment system (1) according to any one of the preceding claims 1-14 for the inspection or treatment of a wound (5) of a subject, wherein the wound (5) comprises one or more injuries selected from the group consisting of a wound, an infected wound, a venous leg ulcer, an arterial leg ulcer, an abrasion, a lesion, a sore, a pressure ulcer, a tunneling wound, a burn wound, a radiation wound, a diabetic ulcer, and a neuropathic ulcer.

20

19. A method for producing a treatment cap (100) as defined in any of the claims 1-17, comprising:

- 3D-printing of a first part of the treatment cap (100), wherein the first part comprises a layer (146) with a cavity (192), wherein the layer further comprises a host position (135) configured for receiving a second light source (130), allowing the second light source (130) to emit second light (131) in the cavity (192), and wherein the layer (146) further comprises tubing (400) configured for providing a fluid connection between the cavity (192) and an element external from the cavity (192);
- arranging a flexible gas permeable sheet (190) in the cavity (192), whereby the cavity (192) is closed and wherein a chamber (140) is defined by the layer (146) and the gas permeable sheet (190) at a first side of the gas permeable sheet (190);
- arranging a second light source (130) in the host position (135), wherein the second light source (130) is configured for providing second light (131) in the cavity (192) at the first side of the gas permeable sheet (190); and

- arranging a first light source (120) to the cap (100) for providing first light (121) emanating from the first light source (120) in a direction away from the gas permeable sheet (190);

5 wherein the sheet is selected to be transmissive to light having a wavelength in the range of 280-1100 nm.

20. The method according to claim 19, further comprising: sensing a wound (5) and skin tissue (2) surrounding the wound (5) prior to 3D printing the first part of the treatment cap (100), wherein the 3D printing of the first part of the treatment cap (100) is
10 based on the sensing.

21. Use of 3D printing to 3D print a user specific designed part of a treatment cap (100) for arrangement over a wound as defined in any one of the claims 1-17.

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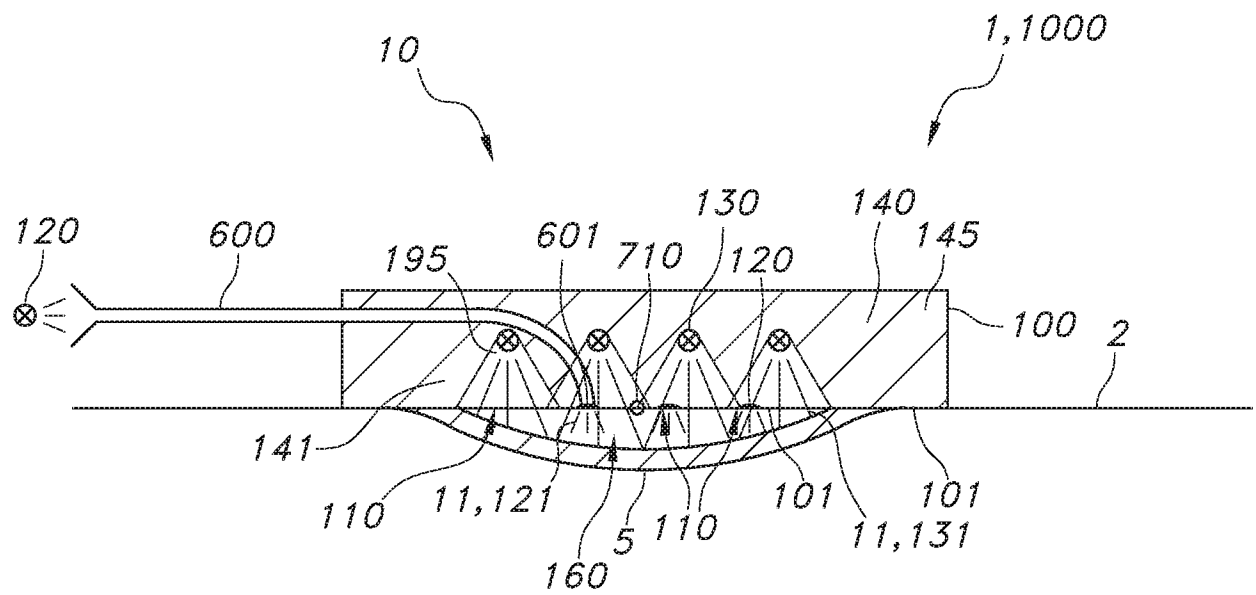


FIG. 1

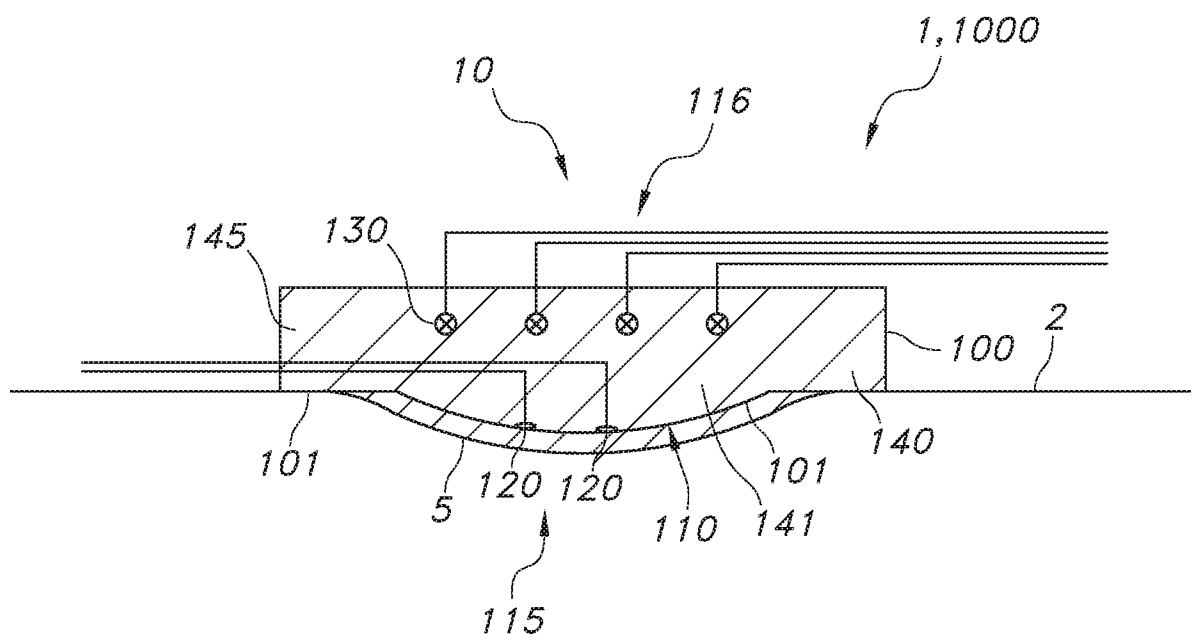
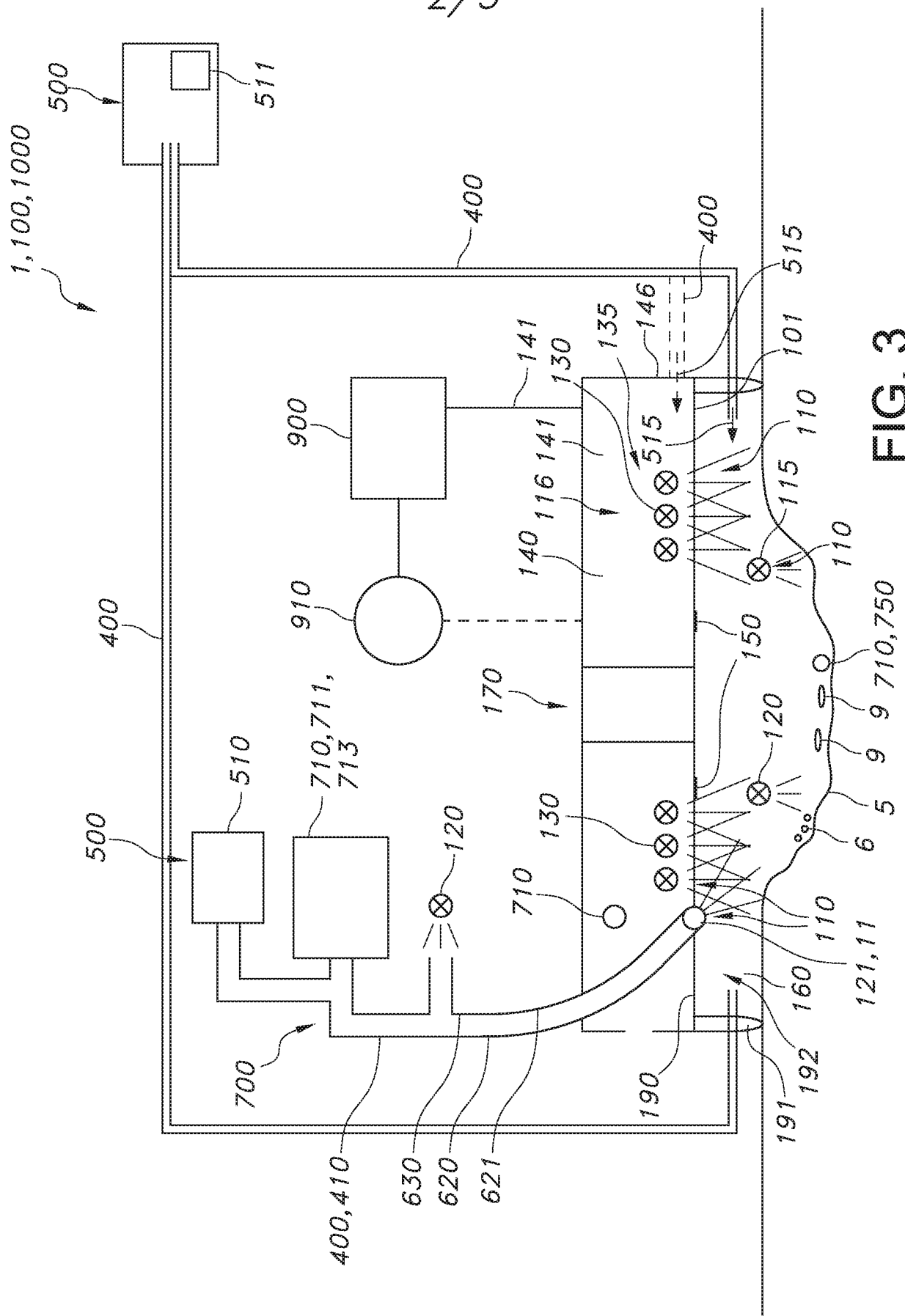
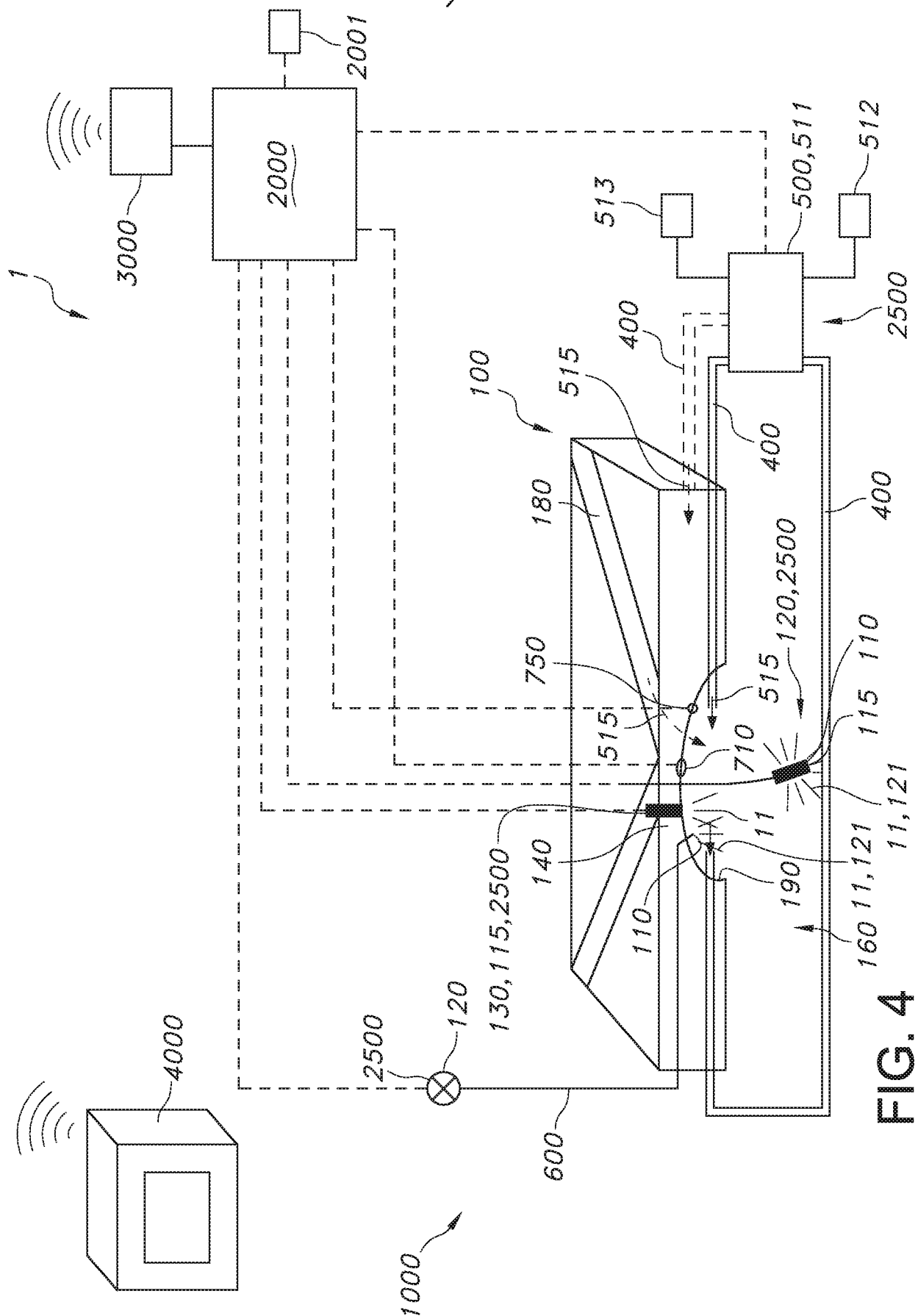


FIG. 2





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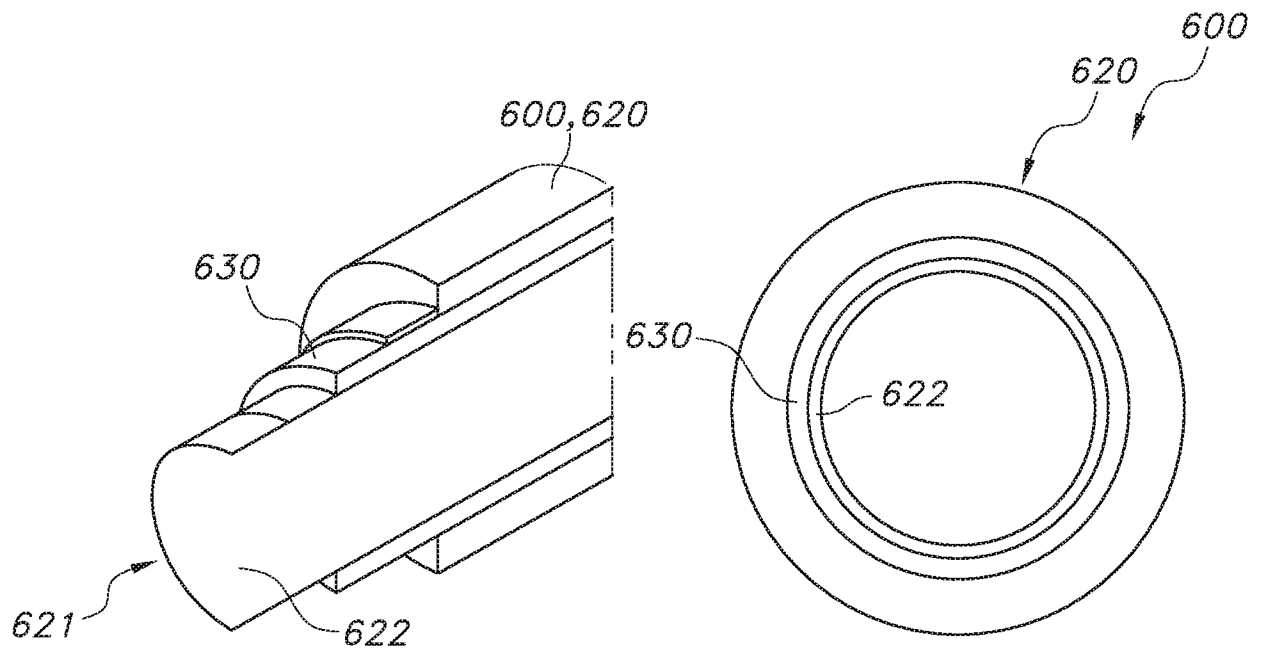
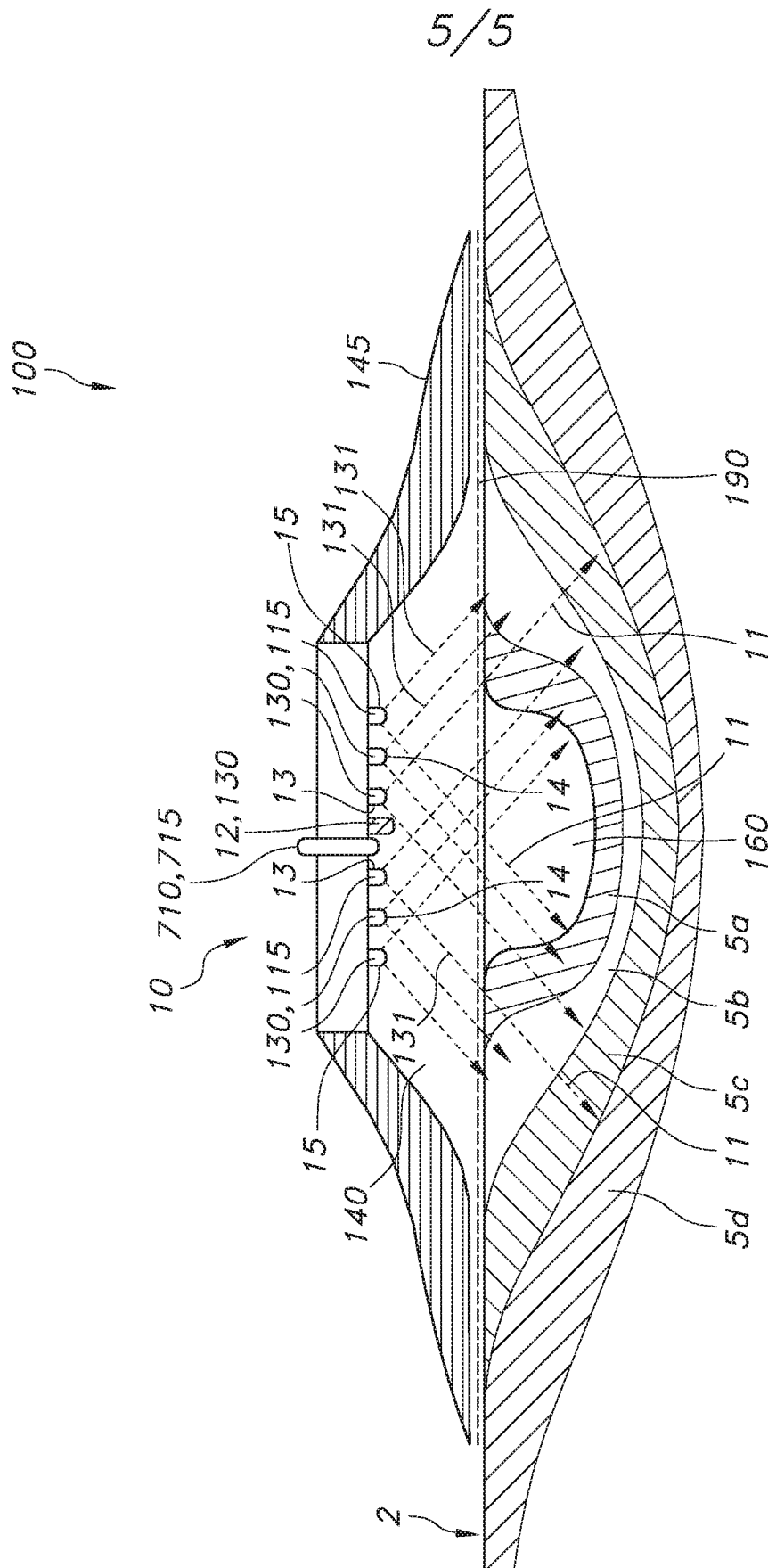


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2019/050392

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61F13/02 A61M1/00 A61F13/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61F A61M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2017/009130 A1 (CARAG AG [CH]) 19 January 2017 (2017-01-19) figures 1,7-11 claim 1 page 3, line 14 - page 4, line 10 page 11, lines 7-18 page 10, line 4 - page 15, line 6 page 5, lines 7-10	1-17, 19-21
A	US 2017/181895 A1 (QUISENBERRY TONY [US]) 29 June 2017 (2017-06-29) paragraphs [0004], [0015]; figures 4,5 paragraphs [0050], [0052] paragraphs [0055] - [0058], [0060], [0064]; figures 8A,9-12 figure 13 abstract ----- -/--	1-17, 19-21



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

29 August 2019

Date of mailing of the international search report

12/09/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Mauhin, Viviane

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2019/050392

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2018/039656 A1 (RIBEIRO ADOLFO [US]; SENTIS NICOLE KERSTIN [DE]; LEWIS ERIC [US]) 1 March 2018 (2018-03-01) paragraphs [0032], [0034], [0038], [0045] -----	1-17, 19-21
A	EP 1 074 275 A1 (ZHAROV VLADIMIR PAVLOVICH [RU]) 7 February 2001 (2001-02-07) figures 3,12 -----	1-17, 19-21
A	US 2008/058907 A1 (REUBEN DAVID I [US]) 6 March 2008 (2008-03-06) the whole document -----	1-17, 19-21
A	WO 2015/130891 A2 (ILLUMICURE INC [US]) 3 September 2015 (2015-09-03) the whole document -----	1-17, 19-21
A	US 2016/015962 A1 (SHOKOUEINEJAD MARAGHEH MEHDI [US] ET AL) 21 January 2016 (2016-01-21) the whole document -----	1-17, 19-21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NL2019/050392

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 18
because they relate to subject matter not required to be searched by this Authority, namely:
Method for treatment of the human or animal body by therapy
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/NL2019/050392

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