intensity to about 37% has occurred, is typically one to five millimeters in biological tissues. A comparably high penetration depth can be achieved when irradiating in the yellow spectral range, i.e., in the wavelength range from 560 to 590 nm. In contrast, the penetration depth greater than 2 µm of ultraviolet, violet and infrared radiation in biological tissues is typically only in the micrometer range.

In an aspect, the present disclosure provides a hand-held device for excitation a hand-held device for excitation and irradiation of pathogenic microorganisms in the mouth and throat, comprising at least one excitation light source in the short-wave visible spectral range for auto-fluorescence excitation and irradiation of the pathogenic microorganisms on the surface, at least one primary irradiation light source in the red spectral range for primary irradiation of the pathogenic microorganisms and for transillumination, and optionally at least one secondary irradiation light source in the visible spectral range from 450 nm to 600 nm, wherein the emitted radiation of the irradiation light sources each have spectral components which can be absorbed by endogenous porphyrins produced by the pathogenic microorganisms, whereby fluorescence formation and inactivation of the pathogenic microorganisms occurs on the basis of subsequent processes, and the hand-held device further comprises a pressure sensor which, upon detection of a pressure of the hand-held device onto the affected surface area, increases an irradiation light intensity to values in a range of 10 mW/cm^2 to 100 mW/cm^2 to achieve inactivation of the pathogenic microorganisms.

According to the disclosure, a hand-held device for the excitation and irradiation of pathogenic microorganisms in the mouth and throat is provided, which comprises at least one excitation light source in the short-wave visible spectral range for auto-fluorescence excitation and irradiation of the pathogenic microorganisms at the surface of the region to be irradiated. The short-wave visible spectral range mentioned herein preferably comprises violet light in a range from 400 nm to 410 nm. Typical light penetration depths in this spectral range are a few hundred micrometers in the tooth, i.e. < 1 mm. Furthermore, the handheld device according to the disclosure comprises at least one primary irradiation light source in the red spectral range, i.e. having a wavelength around 630 nm, both for primary irradiation of the pathogenic microorganisms and for transillumination, i.e. having dual applicability. Furthermore, the handheld device according to the disclosure optionally comprises at least one

secondary irradiation light source in the visible spectral range, preferably green or yellow, for irradiating the pathogenic microorganisms. The excitation light source, as well as the primary and the optional secondary irradiation light source emit appropriate visible radiation, wherein all irradiation light sources have different wavelengths, and the respective emitted radiation is comprised of spectral components which can be absorbed by endogenous porphyrins produced by the pathogenic microorganisms. Thus, fluorescence formation and inactivation of the pathogenic microorganisms can be achieved on the basis of subsequent processes. Besides direct irradiation of the microorganisms for inactivation thereof, radiation of the primary irradiation light source in the red spectral range around 630 nm is additionally also suitable for detecting inflammatory processes in the throat (sinusitis) by transillumination. In other words, the handheld device according to the disclosure comprises at least one violet radiation source (405 nm) and one red radiation source (633nm). Herein, the violet radiation is used for fluorescence excitation and inactivation of bacteria on the surface of the dental hard tissue and soft tissue. On the one hand, the red radiation of the primary irradiation light source is for the already mentioned dual use applicability, for detection of sinusitis

by the altered scattered radiation, which scattered radiation can be detected by transillumination through the skin in the face region, i.e. by those radiation components which are produced by a radiation source introduced into the mouth and which passes the skin and thus can be detected in the face region. In this case, the transillumination image of the pathological area shows a spatially altered and intensity-altered pattern compared to healthy areas. On the other hand, the red radiation also serves to inactivate bacteria in the tissue depth, i.e. in the deeper tissue layers of several millimeters, such as in deeper layers of the hard dental tissue. The hand-held device according to the disclosure also comprises a pressure sensor, the measurement output of which is used to increase an irradiation light intensity of the irradiation light sources to values in a range of from 10 mW/cm^2 to 100 mW/cm^2 when a contact pressure of the hand-held device onto the targeted surface area is detected, to achieve intensification of pathogenic microorganism inactivation. In this way, it can be ensured that no excessive irradiation intensity is emitted by the hand-held device according to the disclosure when the hand-held device is not located in the mouth and throat, especially to avoid irradiation of the eyes of a user with the increased irradiation intensity.

The pathogenic microorganisms, for example corresponding to the pathogenic Gram-positive porphyrin-producing ATCC strains Propionibacterium acnes, Actinomyces odontolyticus and Porphyromonas gingivalis as well as the Prevotella species. Based on the excitation light source, the present hand-held device according to the disclosure enables excitation of intrinsic fluorescence of these pathogenic microorganisms, so that a user can recognize with the naked eye where or on which teeth or tooth areas such pathogenic microorganisms are located. In addition, the excitation light source in the visible short-wave spectral range can already cause initial inactivation of the pathogenic microorganisms. Subsequently, in addition to the transillumination already described, the user is enabled, especially by using the primary and/or the optional secondary irradiation light source, to irradiate the intrinsically fluorescent and other pathogenic microorganisms using wavelengths that are absorbed by the endogenous porphyrins produced by the pathogenic microorganisms. By appropriate subsequent processes initiated by the absorption of this radiation, the microorganisms can be induced to further fluorescence formation, as well as to at least partial, preferably complete inactivation. Consequently, the hand-held device according to the disclosure is suitable for inhibiting the occurrence and propagation of certain pathogenic microorganisms and

for destroying such microorganisms already existing by initiating photodynamic reactions involving endogenous porphyrins. Administration of any exogenous photosensitizer is not further required for this purpose.

According to a preferred embodiment, the excitation light source for auto-fluorescence excitation of the pathogenic microorganisms emits an excitation radiation corresponding to an absorption maximum of porphyrins, wherein the excitation radiation can, for example, be in a range from 400 nm to 410 nm, such as in the range of 405 nm, which corresponds to violet light. In this way, the maximum possible intrinsic fluorescence of the targeted microorganisms can be achieved to enable a user to detect as many microorganism colonies as possible on his tooth surfaces with maximum ease, and to fight them in a targeted manner. However, the radiation does not usually reach a deep penetration depth, so that surface microorganisms can increasingly be targeted and inactivated, due to the property of violet light low light penetration depth into biological soft and hard tissue.

According to another preferred embodiment of the present disclosure, radiation in the visible longer wavelength spectral range is also emitted by the handheld device according to the disclosure. In this case, the irradiation for example has an additional wavelength component in a range from 630 nm to 700 nm, preferably in a range from 630 nm to 635 nm, further preferably light in the range of 633 nm, which corresponds to red light. When radiation in the range of 630 nm to 640 nm is applied, a high penetration depth of the radiation as well as targeted irradiation into an absorption band of the endogenous porphyrins protoporphyrin IX and coproporphyrin is provided, whereby deeper microorganisms may be reached and inactivated. By successive irradiation using the radiation from the excitation light source followed by radiation from the primary irradiation light source having a wavelength component in a range from 630 nm to 700 nm, preferably in a range from 630 nm to 635 nm, further preferably in a range of 633 nm, and optionally also irradiation using the secondary irradiation light source having a wavelength component in a range from 490 nm to 560 nm (green-yellow), preferably in the range of 505 nm, irradiation of the desired area can be achieved in different penetration depths to achieve most extensive possible inactivation of the targeted microorganisms. Optionally, therefore, a third radiation source in the visible range, preferably having green or yellow light, can be used, which preferably is for inactivation

of bacteria surface located and slightly deeper. The light sources may further also emit exclusively in the specified range, continuously or pulsed, but may alternatively emit radiation in a wider visible wavelength range, as well as provide a white light source, if desired. Cancer-causing effects from radiation in the above-mentioned irradiation wavelength ranges are not known. Short-wave visible radiation in the blue or violet spectral range, especially around 405 nm, and in the yellow or green spectral range, especially around 505 nm, can be used as the endogenous porphyrins have absorption bands therein. However, as the irradiation depth is lower than in the red spectral range, only microorganisms in the surface region can predominantly be inactivated by the short-wave visible radiation. When using radiation in the wavelength ranges mentioned above, application of exogenous photosensitizers for inactivating porphyrin-producing pathogenic microorganisms is not required, and the hand-held device according to the disclosure is capable of inactivating the targeted pathogenic microorganisms without further aids, such as exogenous photosensitizers, thereby eliminating potentially arising risks to the user, such as caries, ginigvitis and periodontitis. All radiation sources of the hand-held device according to the disclosure contain spectral components similar to those of endogenous porphyrins, thus being able to initiate fluorescence and photochemical processes for inactivation.

According to another preferred embodiment of the present disclosure, radiation emission of the excitation light source, the primary irradiation light source, and the secondary irradiation light source is performed in the manner of a traffic light circuit. Accordingly, the radiation of the excitation light source is emitted first, for example, at an upper end of the handheld device. Following detection of the intrinsically fluorescent microorganisms and irradiation of the microorganisms with the excitation light source in a surface region, radiation of the primary irradiation light source can subsequently be emitted, for example, located below the excitation light source. Radiation of the optional secondary irradiation light source can subsequently be performed, which secondary irradiation light source can be arranged, for example, below the primary irradiation light source. Accordingly, for example, irradiation of the teeth and the surrounding soft tissue of a user is first performed using excitation radiation at a position on the hand-held device, followed by irradiation of the microorganisms in the mouth and throat of the user using irradiation from the primary irradiation light source at a position located more inferior on the hand-held device, followed by irradiation of the microorganisms in the

mouth and throat of the user using irradiation from the secondary irradiation light source at a position located still more inferior on the hand-held device. Accordingly, such a traffic light circuit of the various light sources of the hand-held device according to the present disclosure can fulfill not only a medical-technical purpose but, in addition, an aesthetic purpose, whereby passing through of the traffic light circuit steps also fulfills a control and controllability purpose regarding correct course of the irradiation.

According to another preferred embodiment of the present disclosure, the handheld device may further comprise at least one light detection device for detecting an intrinsic fluorescence radiation of the pathogenic microorganisms, so that the user is not required to visually detect all intrinsically fluorescent microorganisms, but may pass this task to the light detection device. Accordingly, the light detection device can detect the intrinsic fluorescence of the excited microorganisms and output a corresponding detection signal, for example based on a haptic or acoustic feedback to the user, wherein the strength of the feedback can reflect the intensity of the intrinsic fluorescence. Furthermore, the light detection device can output the detection signal, i.e. the distribution of the fluorescent microorganisms on the user's teeth, to the outside by means of a transmission device, for example via a wireless Bluetooth connection or the like to a computer, a cell phone or the like, by which the user can detect the distribution of the fluorescent microorganisms on his teeth and initiate appropriate steps, especially regarding the need for irradiation using the primary and/or the optional secondary irradiation light source, or also regarding the respective irradiation duration. Fluorescence radiation and transmitted radiation can further be detected by the eye, by CCD cameras such as present in cell phones, and by other photon detectors such as a light diode or a photomultiplier.

According to another preferred embodiment of the present disclosure, the excitation light source, the primary irradiation light source and/or the optional secondary irradiation light source may comprise at least one of a light-emitting diode (LED), an organic light-emitting diode (OLED) and/or a laser. Accordingly, the handheld device according to the disclosure may comprise radiation sources in the form of the excitation light source, the primary irradiation light source and/or the optional secondary irradiation light source, preferably high divergence LEDs. For example, the LEDs may be arranged in the form of an array on or in the handheld device. With the divergence preferably being high, it

can advantageously be achieved that efficient focusing of the light radiation on the retina of the respective eye a user will not be performed when incorrectly applying the irradiation light sources of the hand-held device to the eyes, and accordingly possible damage of the eye region in case of incorrect application of the hand-held device is not likely to occur. By using miniaturized light sources, especially LEDs, power consumption during irradiation can be kept low, and all advantages usually achieved by LEDs, such as the longevity thereof, etc., also apply to the hand-held device according to the disclosure. In addition, the device may be provided with a pressure sensor which is used to switch to higher light intensity not before a pressure will be applied which corresponds to the typical pressure of a toothbrush onto the tooth material during toothbrushing. Preferably, the pressure sensor is arranged in the toothbrush head.

The hand-held device according to the present disclosure preferably is a tooth cleaning device for use during daily dental hygiene, such as a manual toothbrush for manual theeth cleaning or an automatic or electric toothbrush for the automatic teeth cleaning, wherein the excitation light source, the primary irradiation light source and/or the optional secondary irradiation light source may be located in a brush head of the tooth cleaning device and radiation is performed in the bristle direction, that is, in the direction of the bristles extending away from the hand-held device. More specifically, the handheld device may be a manually operated toothbrush, also referred to as a light toothbrush, in which the brush head of the toothbrush may be provided with an interchangeable bristle carrier, or the handheld device may be an electrically operated toothbrush, in which the brush head, which can be set in rotation and/or oscillation, can be replaceable, and wherein a power supply for the electrical drive of the brush head and a power supply for the excitation light source, the primary irradiation light source and/or the secondary irradiation light source can be provided by the same power source.

Alternatively, implementation of the hand-held device in the manner of a temporarily insertable dental plastic splint is conceivable, such as a customized deep-drawn dental plastic splint (covering over teeth and jaw made of translucent plastic), such as an upper head splint or a lower jaw splint, which can be placed over the teeth of a user's jaw, wherein the power source, switch and LED radiation sources can be integrated into the plastic body and positioned at any desired locations on the plastic support. As

another, but not preferred alternative, implementation of the hand-held device for the excitation and irradiation of pathogenic microorganisms in the throat without any cleaning function is also conceivable.

Generally, the above-mentioned excitation light source can be used at low intensity for bacterial detection in the throat by fluorescence activation of porphyrins in the pathogenic microorganisms and at higher intensity for inactivation of pathogenic surface microorganisms. Furthermore, the primary irradiation light source can serve to inactivate deeper pathogenic microorganisms or as a transmission source for transillumination for detection and progression of sinusitis. In addition, the optional secondary irradiation light source may serve to further inactivate pathogenic microorganisms, quasi as a supplemental irradiation in a secondary radiation region. Accordingly, the excitation light source may emit violet light at 405 nm, the primary irradiation light source may emit red light at 633 nm, and the secondary irradiation light source may emit yellow or green light at 505 nm, wherein the violet light and the red light may serve for microorganism detection in the throat region, and the violet light can serve for fluorescence activation of porphyrins in the microorganisms, i.e., it can be used at lower intensity for fluorescence excitation and at higher intensity for inactivation of superficial microorganisms. The red light can also allow detection of inflammatory changes, such as sinusitis, and tracking of progression thereof through transillumination. The green light, similar to the red light at higher intensity, can be used to inactivate microorganisms located in deeper tissue layers. However, higher irradiation light intensities in a range of 10 mW/cm^2 to 100 mW/cm^2 are emitted by the light toothbrush according to the disclosure only when the pressure sensor detects a contact pressure, which signals that the light toothbrush has come into contact with either the tooth surface or the tissue in the mouth and throat for tooth cleaning. Such pressure sensor can be in the form of a piezoresistive or piezoelectric pressure sensor, or also in the form of a Hall-effect pressure sensor, whereby any type of commercially available pressure sensor can be used, which can be installed in the light toothbrush according to the disclosure due to its size and/or mode of operation. Advantageously, the pressure sensor is located in the toothbrush head adjacent to the brushes.

According to the disclosure, the red radiation around 630 nm of the hand-held device according to the disclosure furthermore is to be used for transillumination, wherein the

red radiation at 630 nm is in the optical window of biological tissue and is characterized by a high light penetration depth of several millimeters. The light penetration depth usually is the value where the light intensity has dropped to about 37% of the initial intensity. Many red photons can therefore travel distances of several centimeters. Thus, red radiation can also be transmitted through the skin. The red transilluminated radiation can easily be detected by eye. In addition, any cell phone equipped with a normal CCD camera, for example, or other photon detectors, such as light diodes and photomultipliers (secondary electron multipliers), is also suitable for image acquisition. Thus, sinusitis can be detected and progress thereof can be observed and documented. The handheld device according to the disclosure and use thereof are particularly suitable for children and adolescents. Blood absorbs in the range around 400 nm (Soret band) and in the range 540 nm to 580 nm. The endogenous absorber protoporphyrin absorbs around 405 nm, at 505 nm, 540 nm, 573 nm and 635 nm. In order to obtain penetration depths higher than at 400 nm and to be absorbed by, for example, the protoporphyrin PP IX, light in the range around 505 nm (green) and 633 nm (red) should be used according to the disclosure. This could also be used to inactivate bacteria in the tissue depth, especially in soft tissue. Radiation around 405 nm is used for surface excitation of fluorescence and for inactivation of bacteria on the surface.

According to a preferred embodiment of the present disclosure, the handheld device comprises an energy source integrated for supplying power to the excitation light source, the primary irradiation light source and/or the secondary irradiation light source, such as, for example, a battery or an accumulator, wherein the integrated energy source, when being implemented as an accumulator, can wirelessly be recharged.

In the following description of the preferred embodiments of the disclosure, equal or similar components and elements are designated using equal or similar reference numbers, and repeated description of these components or elements in individual cases will be omitted. The figures only schematically represent the subject matter of the disclosure.

The invention is explained in more detail below while making reference to the figures described below, wherein: