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(54) **SYSTEM AND METHOD FOR ATTENUATING THE EFFECT OF AMBIENT LIGHT ON AN OPTICAL SENSOR**

VORRICHTUNG UND VERFAHREN ZUM MINDEREN DES UMGEBUNGSLICHTEFFEKT AUF EINEN OPTISCHEN SENSOR

SYSTEME ET PROCEDE PERMETTANT D'ATTENUER L'EFFET D'UNE LUMIERE AMBIANTE SUR UN CAPTEUR OPTIQUE

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to optical sensors, and, more specifically, to a system for attenuating the effect of ambient light on an optical sensor.

[0002] An optical sensor is a device that may be used to detect the concentration of an analyte (e.g., oxygen, glucose, or other analyte). U.S. Pat. No. 6,330,464 describes an optical sensor.

[0003] There may be situations when it is desirable to use an optical sensor in an environment where there is a significant amount of ambient light (e.g., the outdoors on a bright, sunny day). In some circumstances, a significant amount of ambient light may negatively affect the accuracy of an optical sensor. Accordingly, what is desired are systems and methods to attenuate the negative effect of ambient light on the functioning of an optical sensor and/or to measure and compensate quantitatively for the ambient light.

[0004] US2002026108 discloses an optical-based sensor for detecting the presence or amount of an analyte using both indicator and reference channels. The sensor has a sensor body with a source of radiation embedded therein. Radiation emitted by the source interacts with indicator membrane indicator molecules proximate the surface of the body. At least one optical characteristic of these indicator molecules varies with analyte concentration. For example, the level of fluorescence of fluorescent indicator molecules or the amount of light absorbed by light-absorbing indicator molecules can vary as a function of analyte concentration. In addition, radiation emitted by the source also interacts with reference membrane indicator molecules proximate the surface of the body. Radiation (e.g., light) emitted or reflected by these indicator molecules enters and is internally reflected in the sensor body. Photosensitive elements within the sensor body generate both indicator channel and reference channel signals to provide an accurate indication of the concentration of the analyte.

[0005] WO0224048 discloses an apparatus for monitoring a plurality of tissue viability parameters of a tissue layer element, in which two different illumination sources are used via a common illumination element in contact with the tissue. One illumination source is used for monitoring blood flow rate and optionally flavoprotein concentration, and collection fibres are provided to receive the appropriate radiation from the tissue. The other illuminating radiation is used for monitoring any one of and preferably all of NADH, blood volume and blood oxygenation state of the tissue element, and collection fibres are provided to receive the appropriate radiation from the tissue. In one embodiment, the wavelengths of the two illumination sources are similar, and common collection fibres for the two illuminating radiations are used. In another embodiment, the respective collection fibres are distanced from the illumination point at different distances correlated to the ratio of the first and second illuminating wavelengths.

[0006] US2002016535 discloses a subcutaneous glucose sensor comprising an infrared emitter which transmits light through a narrow sample of interstitial fluid held in a light transparent sample trough. The sensor can be incorporated with an insulin pump in order to create an insulin delivery and feedback measurement loop system.

[0007] US6201980 discloses an implantable chemical sensor system for medical applications is described which permits selective recognition of an analyte using an expandable biocompatible sensor, such as a polymer, that undergoes a dimensional change in the presence of the analyte. The expandable polymer is incorporated into an electronic circuit component that changes its properties (e.g., frequency) when the polymer changes dimension. As the circuit changes its characteristics, an external interrogator transmits a signal transdermally to the transducer, and the concentration of the analyte is determined from the measured changes in the circuit.

SUMMARY OF THE INVENTION

[0008] The present invention provides systems for attenuating the effect of ambient light on optical sensors and for measuring and compensating quantitatively for the ambient light.

[0009] In one aspect, the present invention provides a sensor, comprising: a housing; a circuit board housed within the housing; at least one photodetector mounted on the circuit board; a light source housed within the housing; a transmitter housed within the housing; and a plurality of indicator molecules disposed on an outer surface of the housing, characterized in that:

said circuit board is a ferrite circuit board.

[0010] In some embodiments, the photodetectors of the optical sensor are mounted to the bottom side of a circuit board and holes are made in the circuit board to provide a way for light from the indicator molecules to reach the photodetectors.

[0011] In another aspect, the present invention provides a combination of a sensor reader and a sensor as defined above, the sensor reader comprising: a receiver for receiving a signal from an optical sensor; and a user interface for receiving input from a user of the sensor reader and for providing the user with information, characterized in that said sensor reader further comprises:

means for determining whether the intensity of the ambient light is greater than a predetermined threshold intensity; and
means for issuing a warning to the user if it is determined that the intensity of the ambient light is greater than the predetermined threshold intensity.

[0012] The above and other features and advantages of the present invention, as well as the structure and operation of preferred embodiments of the present invention, are described in detail below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The accompanying drawings, which are incorporated herein and form part of the specification, help illustrate various embodiments of the present invention and, together with the description, further serve to explain the principles of the invention and to enable a person skilled in the pertinent art to make and use the invention. In the drawings, like reference numbers indicate identical or functionally similar elements. Additionally, the left-most digit(s) of a reference number identifies the drawing in which the reference number first appears.

FIG. 1 shows an optical sensor according to an embodiment of the present invention.

FIG. 2 shows an optical sensor according to another embodiment of the present invention.

FIG. 3 shows the top surface of a circuit board according to an embodiment of the present invention.

FIG. 4 shows the field of view of a photodetector according to an embodiment of the present invention.

FIG. 5 shows a sensor that has been implanted into a patient according to an embodiment of the present invention.

FIG. 6 shows a sensor having outriggers according to an embodiment of the present invention.

FIG. 7 shows a functional block diagram of a sensor reader according to an embodiment of the present invention.

FIG. 8 is a flow chart illustrating a process, according to an embodiment of the present invention, that may be performed by a sensor reader.

FIG. 9 is a flow chart illustrating a process for attenuating the effect of ambient light on readings provided by an optical sensor.

FIG. 10 is a flow chart illustrating a process performed by a sensor according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0014] FIG. 1 shows an optical sensor ("sensor") 110, according to an embodiment of the present invention, that operates based on the fluorescence of fluorescent indicator molecules 116. The sensor 110 includes a sensor housing 112 (sensor housing 112 may be formed from a suitable, optically transmissive polymer material), a matrix layer 114 coated over the exterior surface of the sensor housing 112, with fluorescent indicator molecules 116 distributed throughout the layer 114 (layer 114 can cover all or part of the surface of housing 112); a radiation source 118, e.g. an LED, that emits radiation, including radiation over a range of wavelengths which interact with the indicator molecules 116, i.e., in the case of a fluorescence-based sensor, a wavelength which causes the indicator molecules 116 to fluoresce; and a photodetector 120 (e.g. a photodiode, phototransistor, photoresistor or other photodetector) which, in the case of a fluorescence-based sensor, is sensitive to fluorescent light emitted by the indicator molecules 116 such that a signal is generated by the photodetector 120 in response thereto that is indicative of the level of fluorescence of the indicator molecules. Two photodetectors 120a and 120b are shown to illustrate that sensor 110 may have more than one photodetector.

[0015] The indicator molecules 116 may be coated on the surface of the sensor body or they may be contained within matrix layer 114 (as shown in FIG. 1), which comprises a biocompatible polymer matrix that is prepared according to methods known in the art and coated on the surface of the sensor housing 112. Suitable biocompatible matrix materials, which must be permeable to the analyte, include some methacrylates (e.g., HEMA) and hydrogels which, advantageously, can be made selectively permeableparticularly to the analyte--i.e., they perform a molecular weight cut-off function.

[0016] Sensor 110 may be wholly self-contained. In other words, the sensor may be constructed in such a way that no electrical leads extend into or out of the sensor housing 112 to supply power to the sensor (e.g., for driving the source 118) or to transmit signals from the sensor. Rather, the sensor may include a power source 140 that is wholly embedded or housed within the sensor housing 112 and a transmitter 142 that also is entirely embedded or housed within the sensor housing 112.

[0017] The power source 140 may be an inductor, as may be the antenna for transmitter 142 as described in U.S. Patent No. 6,400,974. The transmitter 142 may be configured to wirelessly transmit data to an external reader (see FIG. 7).

[0018] Other self-contained power sources that can be used include microbatteries; piezoelectrics (which generate a voltage when exposed to mechanical energy such as ultrasonic sound; micro generators; acoustically (e.g., ultrasound) driven generators; and photovoltaic cells, which can be powered by light (infrared).

[0019] As shown in FIG. 1, many of the electro-optical components of sensor 112, including a processor 166, which may include electronic circuitry for controlling, among other components, source 118 and transmitter

142, are secured to a circuit board 170. Circuit board 170 provides communication paths between the components.

[0020] As further illustrated in FIG. 1, an optical filter 134, such as a high pass or band pass filter, preferably is provided on a light-sensitive surface of a photodetector 120. Filter 134 prevents or substantially reduces the amount of radiation generated by the source 118 from impinging on a photosensitive surface of the photodetector 120. At the same time, the filter allows fluorescent light emitted by fluorescent indicator molecules 116 to pass through to strike a photosensitive region of the detector 120. This significantly reduces "noise" in the photodetector signal that is attributable to incident radiation from the source 118.

[0021] However, even though filter 134 may significantly reduce "noise" created by radiation from source 118, filter 134 may not significantly attenuate "noise" from ambient light sources 198, particularly because light that passes through skin has a wavelength that may not be filtered by the filter. That is, filter 134 may not significantly prevent ambient light 199 from hitting a photosensitive surface of a photodetector 120. Accordingly, sensor 110 has other features for dealing with the ambient light.

[0022] For example, substrate 170 of sensor 110 is made of a material that does not propagate stray light or is coated with a finish that prevents it from propagating stray light. Thus, by using such a substrate 170 one can reduce the amount of ambient light reaching the photodetectors 120. In some embodiments, substrate 170 is a ferrite circuit board 170 while in other embodiments not being part of the present invention, substrate 170 may be a conventional circuit board having a finish that prevents the board from propagating light.

[0023] Additionally, in sensor 110 the photodetectors 120 may be mounted to the underside of circuit board 170. This may be done by, for example, a technique known as "flip-chip" mounting. This technique of mounting the photodetectors 120 to the underside of the board 170 permits all light-sensitive surfaces except the top surface of the photodetectors 120 to be more easily covered with a light blocking substance 104 (e.g., a black, light blocking epoxy). However, it is contemplated that photodetectors 120 can be mounted on the topside of circuit board 170, as shown in FIG. 2. Like in the embodiment shown in FIG. 1, in the embodiment shown in FIG. 2 all surfaces except the top surface of the photodetector are covered with light blocking substance 104.

[0024] In embodiments where the photodetectors 120 are mounted to the bottom surface of board 170, a hole for each photodetector 120 is preferably created through board 170. This is illustrated in FIG. 3, which is a top view of board 170. As shown in FIG. 3, the light source 118 is preferably mounted to the top surface 371 of board 170. As further shown in FIG. 3, two holes 301a and 301b have been created through board 170, thereby providing a passageway for light from the indicator molecules to reach the photodetectors 120. The holes in circuit board 170 may be created by, for example, drilling and the like. Preferably, each photodetector 120 is positioned such that its face is directly beneath and covering a hole, as shown in FIG. 1.

[0025] This technique restricts light from entering the photodetectors 120 except from their face and through the hole through the ferrite. As further illustrated in FIG. 1, each hole in the ferrite may be filled with an optical pass filter 134 so that light can only reach a photodetector 120 by passing through the filter 134.

[0026] As mentioned above and illustrated in FIG. 1, the bottom surface and all sides of the photodetectors 120 may be covered with black light blocking epoxy 104. Additionally, to minimize unwanted reflections that might occur from parts on the top surface 371 of the circuit board 170, a black epoxy may be used as a potting for all components not within the far-field pattern of the optical system. Further, black epoxy may be used to encircle the filters 134 for each photodetector 120, thereby preventing light leakage from propagating through a glue joint created by the mechanical tolerance between the filters 134 and circuit board holes 301.

[0027] As further shown in FIG. 1, NIR filters 106a and 106b may be positioned on top of filters 134a and 134b, respectively. Such a configuration would require all light reaching a photodetector 120 to pass through not only filter 134, but also NIR filter 106.

[0028] As FIGS. 1 and 2 make clear, any ambient light that reaches a photodetector 120 must first pass through the matrix 114 containing the indicator molecules and the filters before the light can strike the top surface of the photodetector 120 and, thereby interfere with the optical sensor. Although the matrix 114 is characteristically clear, by increasing the water content of the polymerization reaction, a phase separation occurs which results in a highly porous matrix material 114. The large size of the pores, along with the differential refractive index of the matrix 114(versus the surrounding medium), cause substantial light scattering within the matrix 114. This scatter is beneficial in helping to attenuate any ambient light arriving from an external source before it can enter the sensor housing. Accordingly, in some embodiments of the invention, the process of making the matrix 114 is altered so that the matrix 114 will be highly porous.

[0029] For example, in some embodiments, matrix 114 is produced by (a) combining 400 mLs HEMA with 600 mLs distilled water (a 40:60 ratio), (b) swirling to mix, (c) adding 50 uL 10% ammonium persulfate (APS) (aqueous solution) and 10 uL 50% TEMED (aqueous solution), and (d) polymerizing at room temperature 30 minutes to one hour. This process will produce a highly porous matrix (or "white gel" matrix). Polymerization at higher or lower temperatures can also be used to form a white gel matrix. An example is the formation of a 30:70 gel using 175 uL distilled water + 75 uL HEMA + 8.44 uL VA-044 (2,2'-Azobis[2-(2-imidazolin-2-yl)propane] dihydrochloride) (other free radical initiators such as AIBN (2,2'-Azobisisobutyronitrile) might also be used).

[0030] Another feature of sensor 110 is that at least part of the housing 112 may be doped with organic or inorganic dopants that will cause the doped part of the housing 112 to function as an optical filter. For example, it is contemplated to dope a part of housing 112 with savinyl black, which is an organic light blocking material. If necessary, under certain propagation vectors of ambient light, it is possible to selectively dope the housing 112 in such a way so as to only permit the region directly within the photodetectors' 120 field of view to propagate light. This mechanism would use a "saddle" graft architecture fabricated by the pre-machined encasement procedure.

[0031] By use of the non-transparent material 104 and the non-light propagating circuit board 170, the optical field of view of the photodetectors 120 is controlled and restricted to the region of the indicator matrix installation on the surface of the sensor housing 112. The optical field of view for one photodetector 120(a) of the embodiment shown in FIG. 1 is illustrated in FIG. 4.

[0032] Because light cannot pass through the circuitry from the backside, the sensor 110 can be surgically installed in-vivo so as to orient the optical view of the photodetectors 120 in the most favorable placement to minimize light passing through the skin. For example, in some embodiments, orienting the sensor optical field of view inward toward body core tissue may be most favorable. This is illustrated in FIG. 5. As shown in FIG. 5, the one surface of the photodetector not covered by the non-transparent material 104 (i.e., surface 590) faces inward toward body core tissue 501 and away from the skin 520 to which it is the closest. Because it is possible that this orientation may not be maintained in-vivo following installation (e.g., the sensor might roll during normal limb movement), it is contemplated that in some embodiments it will be advantageous to incorporate anti-roll "outriggers" on the sensor housing 212. FIG. 6 is a front view of sensor 110 with outriggers 610 and 611 attached to sensor housing 212 to prevent rolling.

[0033] In addition to providing an improved optical sensor design that significantly attenuates the effect of ambient light on the proper functioning of the optical sensor 110, the present invention also provides improvements to the external signal reader that receives the output data transmitted from the optical sensor 110. As discussed above, this output data, which carries information concerning the concentration of the analyte in question, may be transmitted wirelessly from sensor 110.

[0034] FIG. 7 illustrates an example of an external reader 701. In the embodiment shown in FIG. 7, the optical sensor 110 is implanted near a patient's wrist and the reader 701 is worn like a watch on the patients arm. That is, reader 701 is attached to a wrist band 790. In some embodiments, reader 701 may be combined with a conventional watch. Preferably, wrist band 790 is an opaque wrist band. By wearing an opaque wrist band 790, the patient will reduce the amount of ambient light reaching the optical sensor.

[0035] As shown in FIG. 7, reader 701 includes a receiver 716, a processor 710, and a user interface 711. The user interface 711 may include a display, such as, for example, a liquid crystal display (LCD) or other type of display. The receiver 716 receives data transmitted from the sensor. The processor 710 may process the received data to produce output data (e.g., a numeric value) that represents the concentration of the analyte being monitored by the sensor.

[0036] For example, in some embodiments, sensor 110 may transmit two sets of data to reader 701. The first set of data may correspond to the output of the photodetectors 120 when the light source 118 is on and the second set of data may correspond to the output of the photodetectors 120 when the light source 118 is off.

[0037] Processor 710 processes these two data sets to produce output data that can be used to determine the concentration of the analyte being monitored by the sensor. For instance, the first set of data may be processed to produce a first result corresponding to the sum of (1) the total amount of light from the indicator molecules that reached the photodetectors 120 and (2) the total amount of ambient light that reached the photodetectors 120. The second set of data may be processed to produce a second result corresponding to the total amount of ambient light that reached the photodetectors 120. The processor 710 may then subtract the second result from the first result, thereby obtaining a final result that corresponds to the total amount of light from the indicator molecules that reached the photodetectors 120. The processor 710 may then use the final result to calculate the concentration of the analyte and cause the user interface 711 to display a value representing the concentration so that the patient can read it.

[0038] Advantageously, reader 701 may include a small photodetector 714. By including photodetector 714 in the reader 701, the reader may monitor the amount of ambient light. Further, the processor can be programmed to output a warning to the patient if the amount of ambient light detected by photodetector 714 is above a pre-determined threshold. For example, if the output of photodetector 714, which may be input into processor 710, indicates that there is a relatively high amount of ambient light, processor 710 may display an alert message on user interface 711 to alert the patient that the sensor may be non-functional due to the high amount of ambient light. The patient can then take the appropriate action. For example, the patient can move to an area where there is less ambient light or shroud the sensor so that less ambient light will reach the sensor.

[0039] FIG. 8 is a flow chart illustrating a process 800 that may be performed by processor 710. Process 800 may begin in step 802, where processor 710 receives an input indicating that a user of reader 701 has requested to obtain a reading from the sensor or where processor 710 automatically determines that it is time to obtain data from the sensor.

[0040] In step 804, processor 710 obtains from photodetector 714 information regarding the intensity of the ambient light. In step 806, processor 710 determines, based on the information obtained in step 804, whether the intensity of the ambient light is such that it is likely the sensor will not be able to function properly. For example, processor 710 may determine whether the intensity of the ambient light is greater than some pre-determined threshold. If the intensity of the ambient light is such that it is likely the sensor will not be able to function properly, then processor 710 proceeds to step 890, otherwise processor 710 proceeds to step 808.

[0041] In step 890, processor 710 issues a warning to the user. For example, processor 710 may display a message on user interface 711 or communicate to the user that there is too much ambient light.

[0042] In step 808, processor 710 activates the sensor. For example, processor 710 may wirelessly provide power to the sensor, send an activation signal to the sensor, or otherwise activate the sensor.

[0043] In step 810, processor 710 obtains data from the sensor. For example, as discussed above, the data received from the sensor may include data corresponding to the output of photodetectors 120 when light source 118 is on and data corresponding to the output of photodetectors 120 when light source 118 is off. Sensor 110 may wirelessly transmit the data to receiver 716, which then provides the data to processor 710.

[0044] In step 812, processor 710 processes the received data to produce a result that, if sensor is operating correctly (e.g., there is not too much ambient light), can be used to calculate the concentration of the analyte being monitored by the sensor. For example, as discussed above, processor 710 may subtract the data corresponding to the output of photodetectors 120 when light source 118 is off from the data corresponding to the output of photodetectors 120 when light source 118 is on to produce a result that can be used to determine the concentration of the analyte being monitored by the sensor.

[0045] In step 814, processor 710 causes information or a message regarding the analyte being sensed by the sensor to be displayed to the user, wherein the information or message is based on the result produced in step 812.

[0046] In addition to providing an improved optical sensor design and an improved reader, the present invention provides an improved method for operating an optical sensor, which method also attenuates the negative effect of ambient light. The method may be used with a conventional optical sensor or with optical sensors according to the present invention. FIG. 9 is a flow chart illustrating a process 900 for attenuating the effect of ambient light on readings provided by an optical sensor.

[0047] Process 900 may begin in step 901, where a determination of the amount of ambient light reaching the photodetector is made. For example, in step 901 a signal produced by one or more photodetectors is obtained during a period of time when the indicator molecules are not in a fluorescent state. In step 902, a determination is made as to whether the amount of ambient light reaching the photodetector is such that it is likely the sensor will not be able to provide an accurate reading. If the amount of ambient light reaching the photodetector is such that it is likely the sensor will not be able to provide an accurate reading, then the process proceeds to step 990, otherwise the process proceeds to step 903.

[0048] In step 990, information indicating that there is too much ambient light is transmitted to a sensor reader. After step 990, the process may end or proceed back to step 902.

[0049] In step 903, the indicator molecules are illuminated for about x amount of time (e.g., 50 or 100 milliseconds). For example, in step 903, the light source 118 may be activated for 100 milliseconds to illuminate the indicator molecules. In one embodiment, the light source is activated using about a 2 milliamp drive current. Next, while the indicator molecules are illuminated, the signal produced by a photodetector 120 is read (step 904).

[0050] Next (step 908), the signal obtained in step 901 is subtracted from the signal obtained in step 904 to produce a new signal, which new signal should better correspond to the concentration of the analyte than the signal read in step 904 because the signal read in step 904 includes not only the light emitted by the indicator molecules but also the ambient light that has reached the photodetector. Next (step 910), the new signal is transmitted to an external reader. After step 910, the process may proceed back to step 901.

[0051] Process 900 may be performed by processor 266. That is, in some embodiments, processor 266 may have software, hardware or a combination of both for performing one or more steps of process 900. For example, processor 266 may include an application specific integrated circuit (ASIC) that is designed to carry out one or more of the steps of process 900.

[0052] FIG. 10 is a flow chart illustrating another process 1000 according to an embodiment of the invention. Process 1000 may begin in step 1002 where light source 118 is turned on for about x amount of time (e.g., 50 or 100 milliseconds). For example, in step 1002, the light source 118 may be activated for 100 milliseconds to illuminate the indicator molecules.

[0053] In step 1004, data corresponding to the outputs produced by photodetectors 120a and 120b while light source 118 is on is transmitted to reader 701. In step 1006, reader 701 receives the data. The data may include a reading from photodetector 120a and a reading from photodetector 120b, which is referred to as the reference photodetector. In step 1008, reader 701 processes the received data to produce a first value. For example, the value may be produced by dividing the reading from photodetector 120a by the reading from photodetector 120b.

[0054] Next, light source 118 is turned off (step 1010). In step 1012, data corresponding to the outputs produced by photodetectors 120a and 120b while light source 118 is off is transmitted to reader 701. In step 1014, reader 701 receives the data. The data may include a reading from photodetector 120a and a reading from photodetector 120b.

[0055] In step 1016, reader 701 processes the received data to produce a second value. For example, the second value may be produced by dividing the reading from photodetector 120a by the reading from photodetector 120b. In step 1018, reader 701 subtracts the second value from the first value to obtain a result that can be used to determine the concentration of the analyte being monitored by the sensor. In step 1020, reader 701 displays information concerning the concentration of the analyte (e.g., it displays a value representing the determined concentration).

[0056] Although the above described processes are illustrated as a sequence of steps, it should be understood by one skilled in the art that at least some of the steps need not be performed in the order shown, and, furthermore, some steps may be omitted and additional steps added.

[0057] While various embodiments/variations of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

Claims

1. A sensor (110), comprising: a housing (112); a circuit board (170) housed within the housing (112); at least one photodetector (120) mounted on the circuit board (170); a light source (118) housed within the housing (112); a transmitter (142) housed within the housing (112); and a plurality of indicator molecules (116) disposed on an outer surface of the housing, **characterized in that**:

said circuit board (170) is a ferrite circuit board.

2. The sensor (110) of claim 1, wherein the circuit board (170) has a hole (301) defining a passageway from a top surface of the circuit board (170) to a bottom surface of the circuit board (170).

3. The sensor (110) of claim 2, wherein the at least one photodetector (120) is mounted to the bottom surface of the circuit board (170), the at least one photodetector (120) having a light sensitive surface, said light sensitive surface being positioned so that light travelling through said passageway (301) can strike said light sensitive surface.

4. The sensor (110) of any preceding claim, further comprising an optical filter (134), wherein at least a portion of said optical filter (134) is disposed within said passageway (301).

5. The sensor (110) of claim 4, wherein the optical filter (134) is a high pass filter.

6. The sensor (110) of claim 4 or 5, further comprising a second optical filter (106) disposed in series with the first optical filter (134).

7. The sensor (110) of claim 6, wherein the second optical filter (106) is a NIR filter.

8. The sensor (110) of any preceding claim, wherein the light source (118) is mounted on a top surface (371) of the circuit board (170).

9. The sensor (110) of any preceding claim, further comprising a light blocking material (104) disposed to prevent light from striking one or more sides of said at least one photodetector (120).

10. The sensor (110) of claim 9, wherein the light blocking material (104) comprises a black epoxy.

11. The sensor (110) of any preceding claim, wherein the indicator molecules (116) are contained within a polymer matrix layer (114) that is disposed on the outer surface of the housing.

12. The sensor (110) of claim 11, wherein the polymer matrix layer (114) is highly porous.

13. The sensor (110) of any preceding claim, further comprising:

means (166) for capturing a first signal output from the at least one photodetector (120) while the indicator molecules (116) are in a fluorescent state, wherein said first signal is a function of the intensity of the light striking a photosensitive surface or surfaces of the at least one photodetector (120); and

means (166) for capturing a second signal output from the at least one photodetector (120) while the indicator molecules (116) are not being illuminated, wherein said second signal is a function of the intensity of the light striking a photosensitive surface or surfaces of the at least one photodetector (120).

14. The sensor (110) of claim 13, further comprising means for generating a third signal, wherein the third signal is a function of the first and second signal.

15. The sensor (110) of claim 14, wherein the means for generating the third signal comprises means for subtracting the second signal from the first signal.

16. The sensor (110) of any of claims 13 to 15, further comprising a transmitter (142) for transmitting the first and second signal to a sensor reader.

17. The sensor (110) of any preceding claim, further comprising means for activating a light source (118) by driving the light source (118) with about 2 milliamps of current.

18. A combination of a sensor reader (701) and a sensor (110) according to any preceding claim, the sensor reader (701) comprising: a photodetector (714); a receiver (716) for receiving a signal from an optical sensor (110); and a user interface (711) for receiving input from a user of the sensor reader (701) and for providing the user with information, **characterized in that** said sensor reader (701) further comprises:

means (710) for determining whether the intensity of the ambient light is greater than a predetermined threshold intensity; and
means (710) for issuing a warning to the user if it is determined that the intensity of the ambient light is greater than the predetermined threshold intensity.

19. The combination of claim 18, further comprising means for activating the sensor (110) in response to the determining means determining that the intensity of the ambient light is less than the predetermined threshold intensity.

20. The combination of claim 19, wherein, after the sensor (110) is activated, the receiver (716) receives a signal transmitted from the optical sensor (110), wherein the signal contains information relating to an analyte.

21. The combination of claim 20, further comprising means for using information contained in the signal and the determined intensity of the ambient light to compute a value relating to the analyte.

22. The combination of claim 20, further comprising means for outputting information to the user via the user interface (711), wherein the outputted information is a function of the information contained in the signal received from the optical sensor (110).

23. The combination of claim 20, wherein the signal is transmitted wirelessly.

24. The combination of any of claims 18 to 23, further comprising a housing for housing the receiver (716) and a user interface (711).

25. The combination of claim 24, further comprising an opaque wrist band (790), wherein the housing is attached to the opaque wrist band (790).

Patentansprüche

1. Sensor (110), der Folgendes umfasst: ein Gehäuse (112); eine Leiterplatte (170), die innerhalb des Gehäuses (112) untergebracht ist; mindestens einen Fotodetektor (120), der auf der Leiterplatte (170) angebracht ist; eine Lichtquelle (118), die innerhalb des Gehäuses (112) untergebracht ist; einen Sender (142), der innerhalb des Gehäuses (112) untergebracht ist; und mehrere Indikatormoleküle (116), die auf einer Außenfläche des Gehäuses angeordnet sind, **dadurch gekennzeichnet, dass**:

die Leiterplatte (170) eine Ferritleiterplatte ist.

2. Sensor (110) nach Anspruch 1, wobei die Leiterplatte (170) ein Loch (301) aufweist, das einen Durchgang von einer oberen Fläche der Leiterplatte (170) zu einer unteren Fläche der Leiterplatte (170) definiert.

3. Sensor (110) nach Anspruch 2, wobei der mindestens eine Fotodetektor (120) an der unteren Fläche der Leiterplatte (170) angebracht ist, wobei der mindestens eine Fotodetektor (120) eine lichtempfindliche Fläche aufweist, wobei die lichtempfindliche Fläche derart positioniert ist, dass Licht, das sich durch den Durchgang (301) bewegt, auf die lichtempfindliche Fläche auftreffen kann.

4. Sensor (110) nach einem der vorhergehenden Ansprüche, der ferner ein optisches Filter (134) umfasst, wobei mindestens ein Abschnitt des optischen Filters (134) innerhalb des Durchgangs (301) angeordnet ist.

5. Sensor (110) nach Anspruch 4, wobei das optische Filter (134) ein Hochpassfilter ist.

6. Sensor (110) nach Anspruch 4 oder 5, der ferner ein zweites optisches Filter (106) umfasst, das in Reihe mit dem ersten optischen Filter (134) angeordnet ist.

7. Sensor (110) nach Anspruch 6, wobei das zweite optische Filter (106) ein NIR-Filter ist.

8. Sensor (110) nach einem der vorhergehenden Ansprüche, wobei die Lichtquelle (118) auf einer oberen Fläche (371) der Leiterplatte (170) angebracht ist.

9. Sensor (110) nach einem der vorhergehenden Ansprüche, der ferner ein lichtsperrendes Material (104) umfasst, das angeordnet ist, um zu verhindern, dass Licht auf eine oder mehr Seiten von dem mindestens einen Fotodetektor (120) auftrifft.

10. Sensor (110) nach Anspruch 9, wobei das lichtsperrende Material (104) ein schwarzes Epoxid umfasst.

11. Sensor (110) nach einem vorhergehenden Anspruch, wobei die Indikatormoleküle (116) innerhalb einer Polymer-Matrix-Schicht (114) enthalten sind, die auf der Außenfläche des Gehäuses angeordnet ist.

12. Sensor (110) nach Anspruch 11, wobei die Polymer-Matrix-Schicht (114) hochporös ist.

13. Sensor (110) nach einem vorhergehenden Anspruch, der ferner Folgendes umfasst:

Mittel (116) zum Erfassen eines ersten Signals, das von dem mindestens einen Fotodetektor (120) ausgegeben wird, während die Indikatormoleküle (116) sich in einem fluoreszierenden Zustand befinden, wobei das erste Signal eine Funktion der Stärke des Lichts ist, das auf eine lichtempfindliche Fläche oder Flächen von dem mindestens einen Fotodetektor (120) auftrifft; und

Mittel (166) zum Erfassen eines zweiten Signals, das von dem mindestens einen Fotodetektor (120) ausgegeben wird, während die Indikatormoleküle (116) nicht beleuchtet werden, wobei das zweite Signal eine Funktion der Stärke des Lichts ist, das auf eine lichtempfindliche Fläche oder Flächen von dem mindestens einen Fotodetektor (120) auftrifft.

14. Sensor (110) nach Anspruch 13, der ferner Mittel zum Erzeugen eines dritten Signals umfasst, wobei das dritte Signal eine Funktion des ersten und des zweiten Signals ist.

15. Sensor (110) nach Anspruch 14, wobei das Mittel zum Erzeugen des dritten Signals Mittel zum Subtrahieren des zweiten Signals vom ersten Signal umfasst.

16. Sensor (110) nach einem der Ansprüche 13 bis 15, der ferner einen Sender (142) zum Senden des ersten und zweiten Signals an einen Sensorleser umfasst.

17. Sensor (110) nach einem vorhergehenden Anspruch, der ferner Mittel zum Aktivieren einer Lichtquelle (118) durch Ansteuern der Lichtquelle (118) mit etwa 2 Milliampere Strom umfasst.

18. Kombination eines Sensorlesers (701) und eines Sensors (110) nach einem vorhergehenden Anspruch, wobei der Sensorleser (701) Folgendes umfasst: einen Fotodetektor (714); einen Empfänger (716) zum Empfangen eines Signals von einem optischen Sensor (110); und eine Benutzeroberfläche (711) zum Empfangen von Eingaben von einem Benutzer des Sensorlesers (701) und zum Bereitstellen von Informationen für den Benutzer, **dadurch gekennzeichnet, dass** der Sensorleser (701) ferner Folgendes umfasst:

Mittel (710) zum Bestimmen, ob die Stärke des Umgebungslichts höher ist als eine vorbestimmte Schwellenstärke; und

Mittel (710) zum Ausgeben einer Warnung an den Benutzer, wenn bestimmt wird, dass die Stärke des Umgebungslichts höher als die vorbestimmte Schwellenstärke ist.

19. Kombination nach Anspruch 18, die ferner Mittel zum Aktivieren des Sensors (110) als Reaktion auf das Bestimmen, dass die Stärke des Umgebungslichts niedriger als die vorbestimmte Schwellenstärke ist, durch die Bestimmungsmittel umfasst.

20. Kombination nach Anspruch 19, wobei, nachdem der Sensor (110) aktiviert wurde, der Empfänger (716) ein von dem optischen Sensor (110) gesendetes Signal empfängt, wobei das Signal Informationen enthält, die einen Analyt betreffen.

21. Kombination nach Anspruch 20, die ferner Mittel zum Verwenden von Informationen, die in dem Signal enthalten sind, und der bestimmten Stärke des Umgebungslichts umfasst, um einen Wert zu berechnen, der den Analyt betrifft.

22. Kombination nach Anspruch 20, die ferner Mittel zum Ausgeben von Informationen an den Benutzer über die Benutzeroberfläche (711) umfasst, wobei die ausgegebenen Informationen eine Funktion der Informationen sind, die in dem von dem optischen Sensor (110) empfangenen Signal enthalten sind.

23. Kombination nach Anspruch 20, wobei das Signal drahtlos gesendet wird.

24. Kombination nach einem der Ansprüche 18 bis 23, die ferner ein Gehäuse zum Unterbringen des Empfängers (716) und einer Benutzeroberfläche (711) umfasst.

25. Kombination nach Anspruch 24, die ferner ein lichtundurchlässiges Armband (790) umfasst, wobei das Gehäuse an dem lichtundurchlässigen Armband (790) befestigt ist.

Revendications

1. Capteur (110), comprenant : un logement (112) ; une carte de circuit (170) logée à l'intérieur du logement (112) ; au moins un photodétecteur (120) monté sur la carte de circuit (170) ; une source de lumière (118) logée à l'intérieur du logement (112) ; un émetteur (142) logé à l'intérieur du logement (112) ; et une pluralité de molécules indicatrices (116) disposées sur une surface extérieure du logement, **caractérisé en ce que** :

   ladite carte de circuit (170) est une carte de circuit de ferrite.

2. Capteur (110) selon la revendication 1, dans lequel la carte de circuit (170) comporte un trou (301) définissant une voie de passage à partir d'une surface supérieure de la carte de circuit (170) jusqu'à une surface inférieure de la carte de circuit (170).

3. Capteur (110) selon la revendication 2, dans lequel l'au moins un photodétecteur (120) est monté sur la surface inférieure de la carte de circuit (170), l'au moins un photodétecteur (120) comportant une surface sensible à la lumière, ladite surface sensible à la lumière étant positionnée de sorte que la lumière se déplaçant à travers ladite voie de passage (301) puisse frapper ladite surface sensible à la lumière.

4. Capteur (110) selon l'une quelconque des revendications précédentes, comprenant en outre un filtre optique (134), dans lequel au moins une portion dudit filtre optique (134) est disposée à l'intérieur de ladite voie de passage (301).

5. Capteur (110) selon la revendication 4, dans lequel le filtre optique (134) est un filtre passe-haut.

6. Capteur (110) selon la revendication 4 ou 5, comprenant en outre un deuxième filtre optique (106) disposé en série avec le premier filtre optique (134).

7. Capteur (110) selon la revendication 6, dans lequel le deuxième filtre optique (106) est un filtre de proche infrarouge, NIR.

8. Capteur (110) selon l'une quelconque des revendications précédentes, dans lequel la source de lumière (118) est montée sur une surface supérieure (371) de la carte de circuit (170).

9. Capteur (110) selon l'une quelconque des revendications précédentes, comprenant en outre une matière de blocage de lumière (104) disposée pour empêcher que la lumière ne frappe un ou plusieurs côtés dudit au moins un photodétecteur (120).

10. Capteur (110) selon la revendication 9, dans lequel la matière de blocage de lumière (104) comprend un époxy noir.

11. Capteur (110) selon l'une quelconque des revendications précédentes, dans lequel les molécules indicatrices (116) sont contenues à l'intérieur d'une couche de matrice de polymère (114) qui est disposée sur la surface extérieure du logement.

12. Capteur (110) selon la revendication 11, dans lequel la couche de matrice de polymère (114) est hautement poreuse.

13. Capteur (110) selon l'une quelconque des revendications précédentes, comprenant en outre :

    un moyen (166) pour acquérir un premier signal délivré par l'au moins un photodétecteur (120) pendant que les molécules indicatrices (116) se trouvent dans un état fluorescent, dans lequel ledit premier signal est une fonction de l'intensité de la lumière frappant une ou plusieurs surfaces photosensibles de l'au moins un photodétecteur (120) ; et
    un moyen (166) pour acquérir un deuxième signal délivré par l'au moins un photodétecteur (120) pendant que les molécules indicatrices (116) ne sont pas illuminées, dans lequel ledit deuxième signal est une fonction de l'intensité de la lumière frappant une ou plusieurs surfaces photosensibles de l'au moins un photodétecteur (120).

14. Capteur (110) selon la revendication 13, comprenant en outre un moyen pour générer un troisième signal, dans lequel le troisième signal est une fonction du premier signal et du deuxième signal.

15. Capteur (110) selon la revendication 14, dans lequel le moyen pour générer le troisième signal comprend un moyen pour soustraire le deuxième signal au premier signal.

16. Capteur (110) selon l'une quelconque des revendications 13 à 15, comprenant en outre un émetteur (142) pour transmettre le premier signal et le deuxième signal à un lecteur de capteur.

17. Capteur (110) selon l'une quelconque des revendications précédentes, comprenant en outre un moyen pour activer une source de lumière (118) en entraînant la source de lumière (118) avec environ deux milliampères de courant.

18. Combinaison d'un lecteur de capteur (701) et d'un capteur (110) selon l'une quelconque des revendications précédentes, le lecteur de capteur (701)

comprenant : un photodétecteur (714) ; un récepteur (716) pour recevoir un signal d'un capteur optique (110) ; et une interface utilisateur (711) pour recevoir une entrée d'un utilisateur du lecteur de capteur (701) et pour fournir des informations à l'utilisateur, **caractérisée en ce que** ledit lecteur de capteur (701) comprend en outre :

un moyen (710) pour déterminer si l'intensité de la lumière ambiante est supérieure à une intensité de seuil prédéterminée ; et
un moyen (710) pour émettre un avertissement à l'utilisateur s'il est déterminé que l'intensité de la lumière ambiante est supérieure à l'intensité de seuil prédéterminée.

19. Combinaison selon la revendication 18, comprenant en outre un moyen pour activer le capteur (110) en réponse à la détermination par le moyen de détermination que l'intensité de la lumière ambiante est inférieure à l'intensité de seuil prédéterminée.

20. Combinaison selon la revendication 19, dans laquelle, après l'activation du capteur (110), le récepteur (716) reçoit un signal transmis par le capteur optique (110), dans laquelle le signal contient des informations relatives à un analyte.

21. Combinaison selon la revendication 20, comprenant en outre un moyen pour utiliser des informations contenues dans le signal et l'intensité déterminée de la lumière ambiante pour calculer une valeur relative à l'analyte.

22. Combinaison selon la revendication 20, comprenant en outre un moyen pour délivrer des informations à l'utilisateur par l'intermédiaire de l'interface utilisateur (711), dans laquelle les informations délivrées sont une fonction des informations contenues dans le signal reçu à partir du capteur optique (110).

23. Combinaison selon la revendication 20, dans laquelle le signal est transmis sans fil.

24. Combinaison selon l'une quelconque des revendications 18 à 23, comprenant en outre un logement pour loger le récepteur (716) et une interface utilisateur (711).

25. Combinaison selon la revendication 24, comprenant en outre un bracelet opaque (790), dans lequel le logement est attaché au bracelet opaque (790).

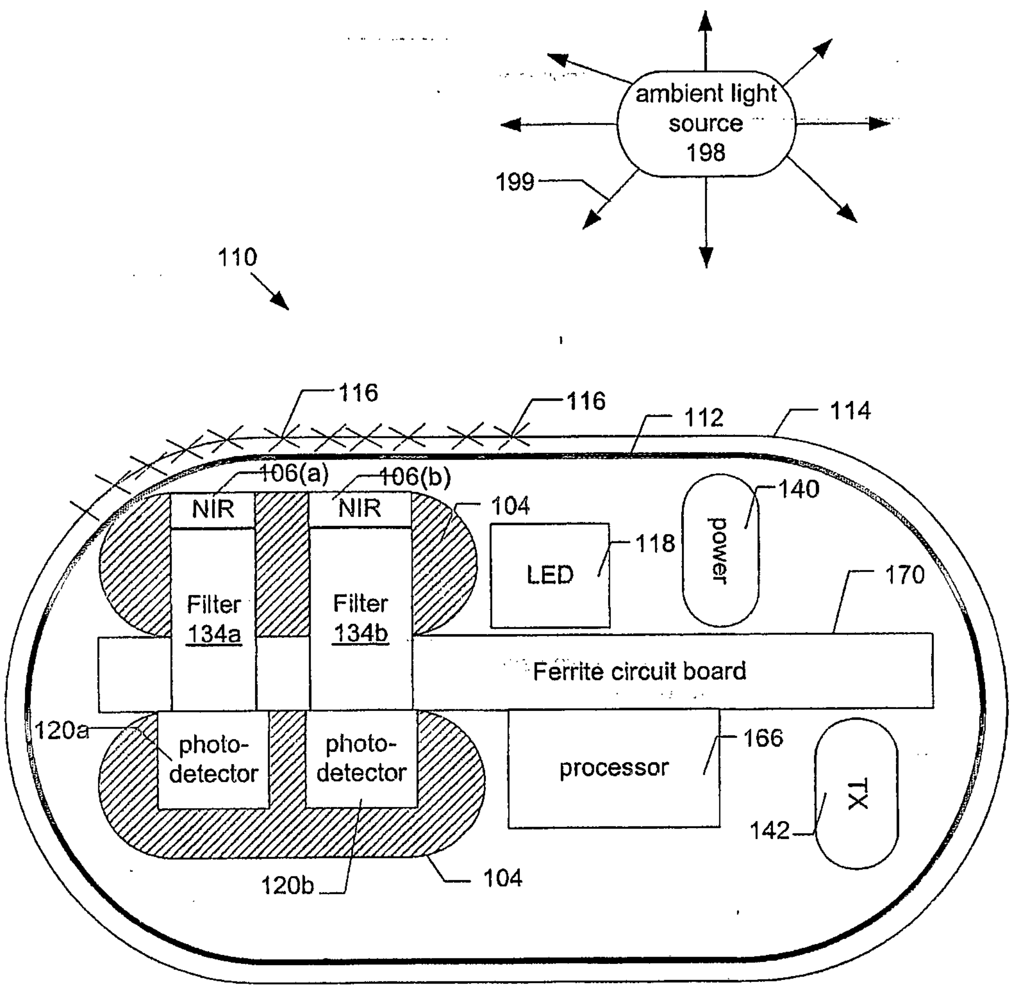
ambient light source 198
199
110
116
116
112
114
106(a)
106(b)
NIR
NIR
104
140
power
LED
118
170
Filter 134a
Filter 134b
Ferrite circuit board
120a
photo-detector
photo-detector
processor
166
TX
142
120b
104

FIG. 1

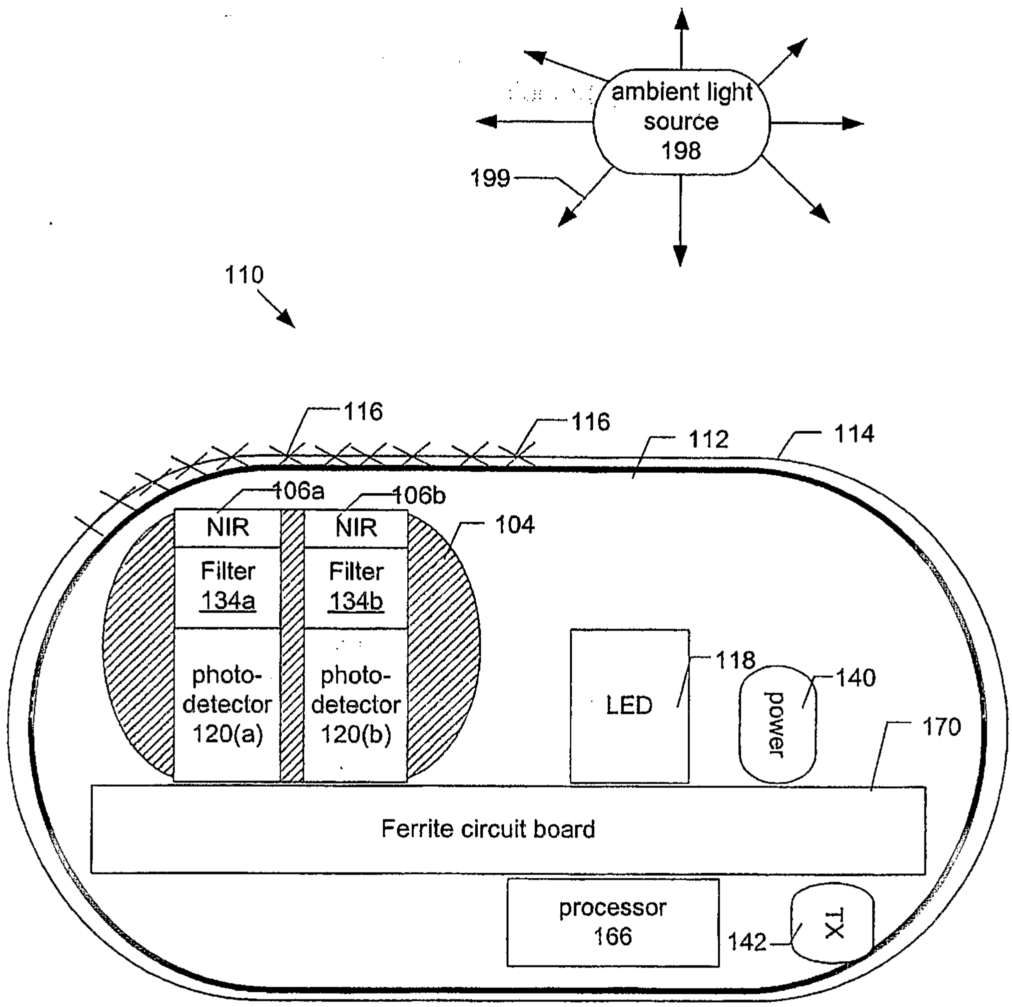
ambient light source 198
199
110
116
116
112
114
106a
106b
NIR
NIR
104
Filter 134a
Filter 134b
photo-detector 120(a)
photo-detector 120(b)
LED
118
140
power
170
Ferrite circuit board
processor 166
142
TX

FIG. 2

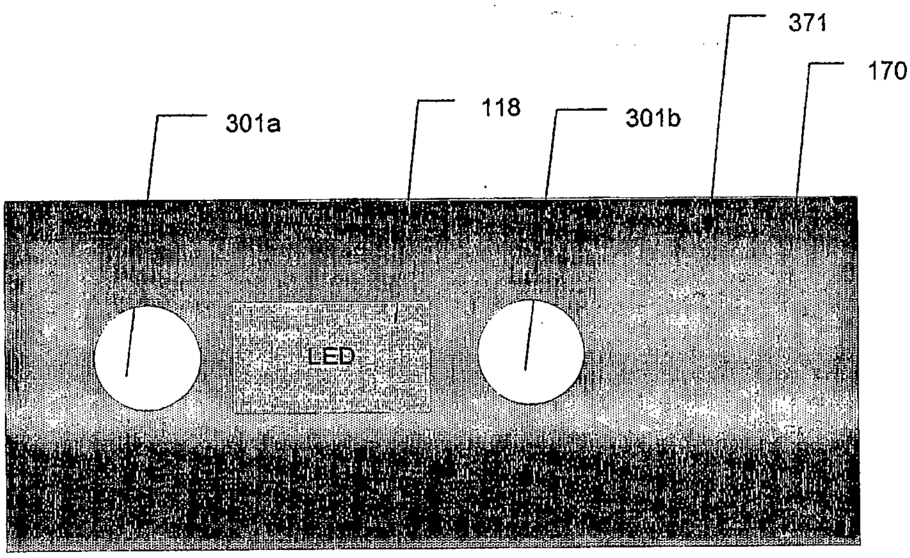

FIG. 3

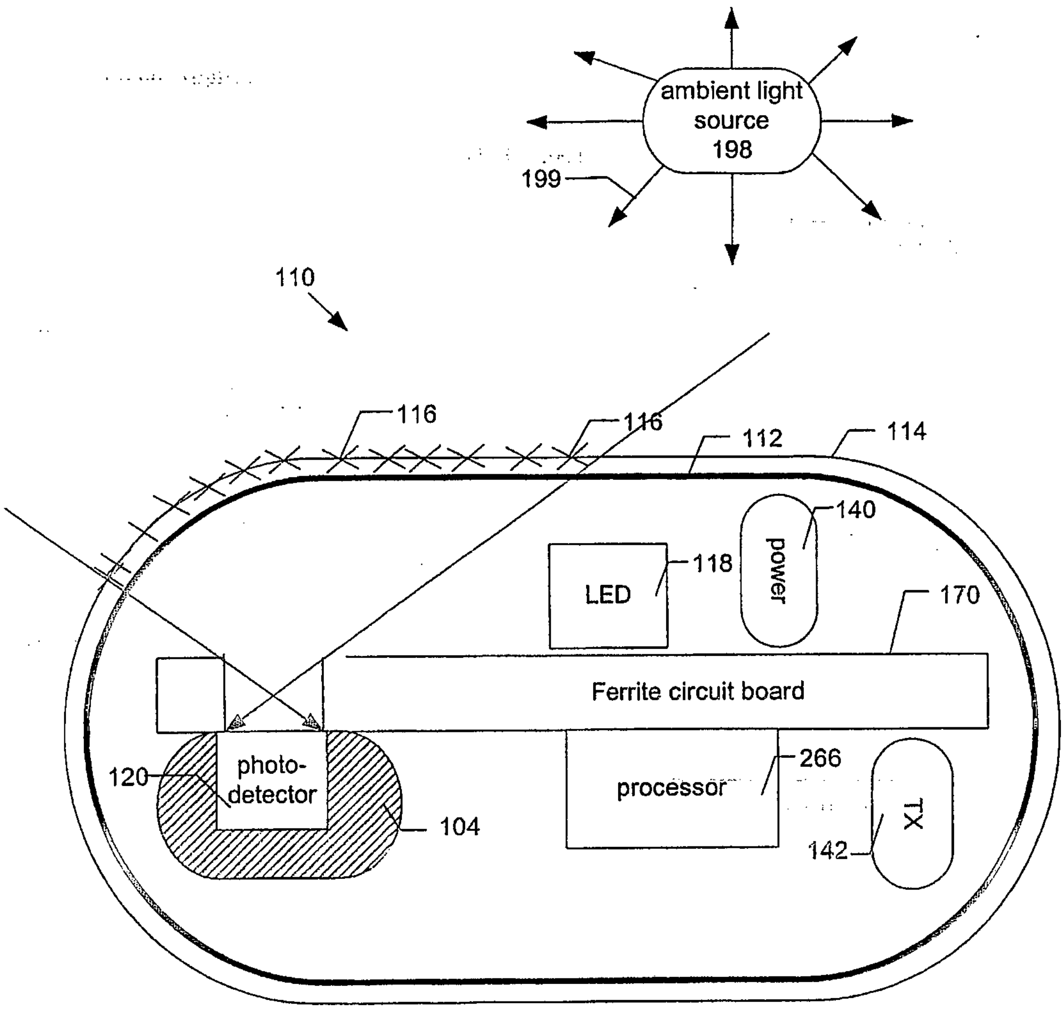
ambient light source 198
199
110
116
116
112
114
140
power
118
LED
170
Ferrite circuit board
photo-detector
120
104
266
processor
TX
142

FIG. 4

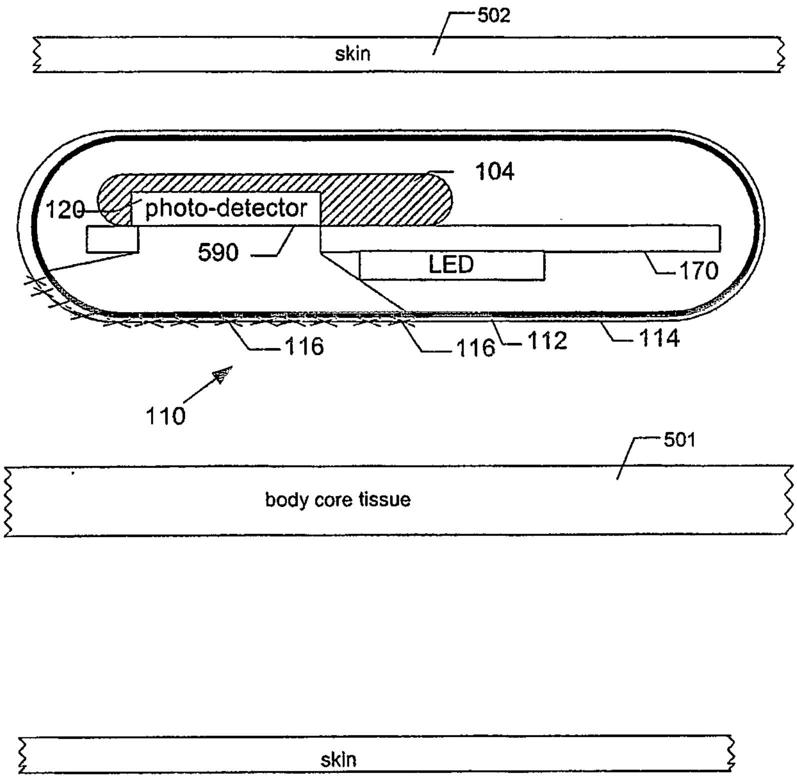
502
skin
104
120
photo-detector
590
LED
170
116
116
112
114
110
501
body core tissue
skin

FIG. 5

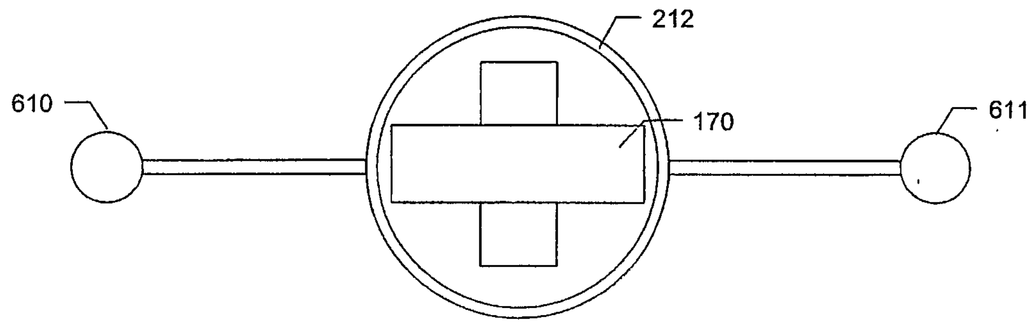

FIG. 6

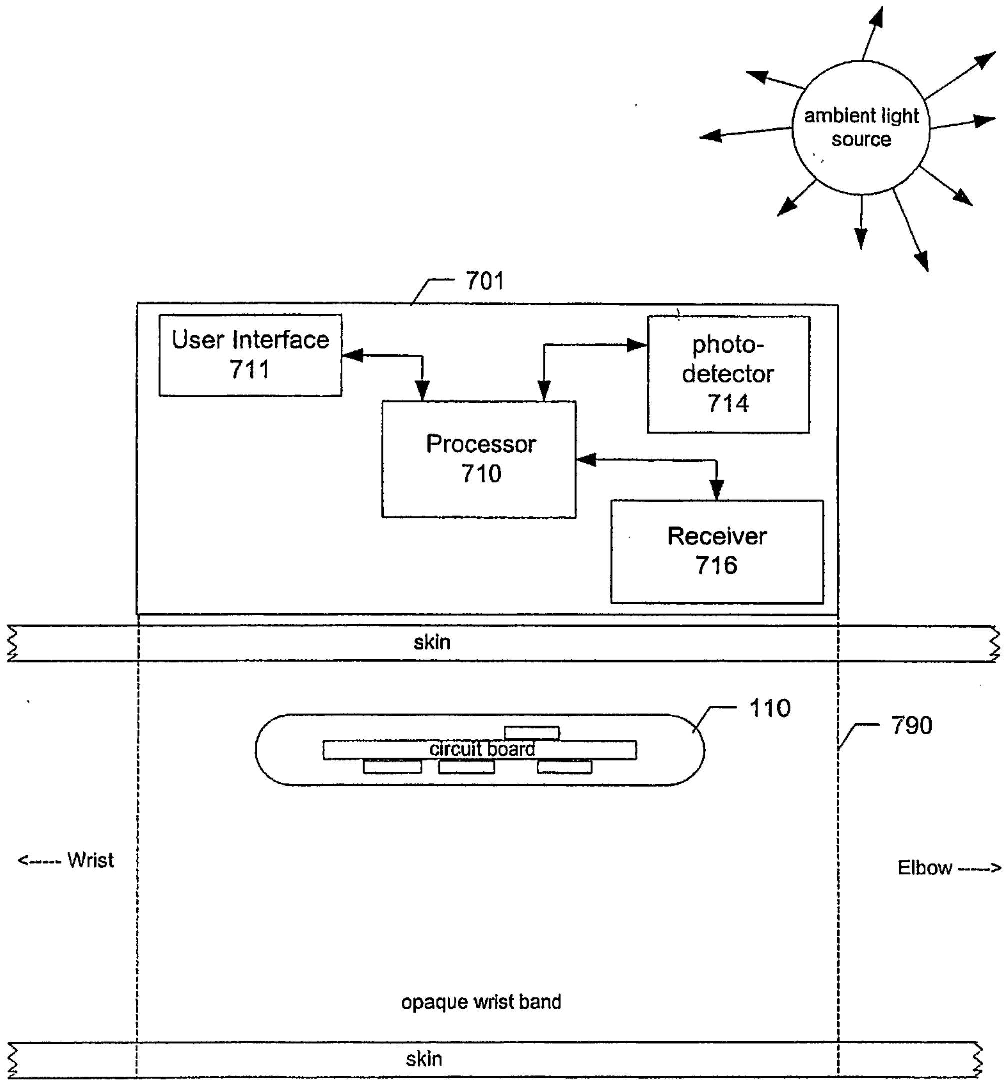
ambient light source
701
User Interface 711
photo-detector 714
Processor 710
Receiver 716
skin
110
circuit board
790
<----- Wrist
Elbow ----->
opaque wrist band
skin

FIG. 7

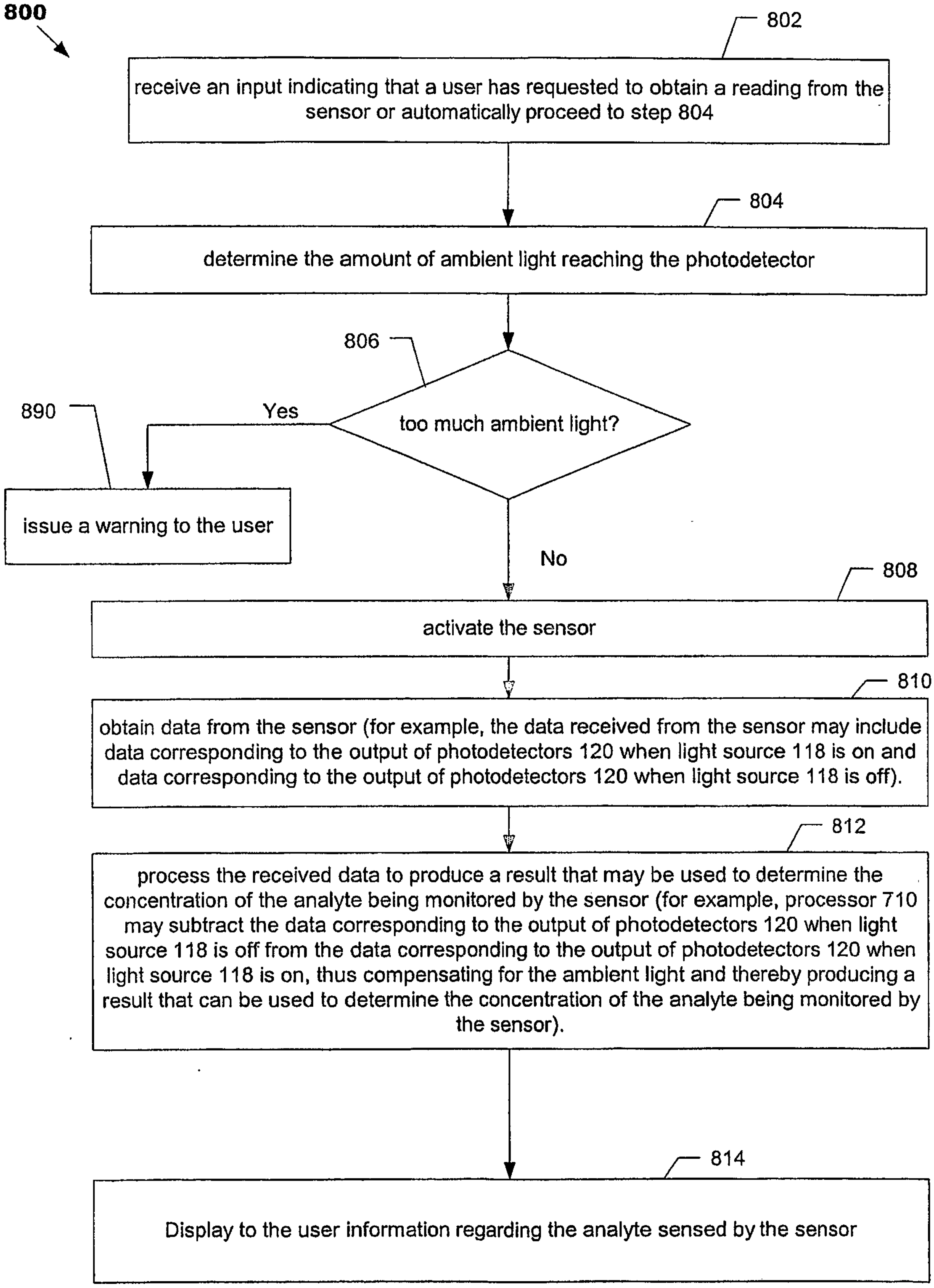
800
802
receive an input indicating that a user has requested to obtain a reading from the sensor or automatically proceed to step 804
804
determine the amount of ambient light reaching the photodetector
806
too much ambient light?
Yes
890
issue a warning to the user
No
808
activate the sensor
810
obtain data from the sensor (for example, the data received from the sensor may include data corresponding to the output of photodetectors 120 when light source 118 is on and data corresponding to the output of photodetectors 120 when light source 118 is off).
812
process the received data to produce a result that may be used to determine the concentration of the analyte being monitored by the sensor (for example, processor 710 may subtract the data corresponding to the output of photodetectors 120 when light source 118 is off from the data corresponding to the output of photodetectors 120 when light source 118 is on, thus compensating for the ambient light and thereby producing a result that can be used to determine the concentration of the analyte being monitored by the sensor).
814
Display to the user information regarding the analyte sensed by the sensor

FIG. 8

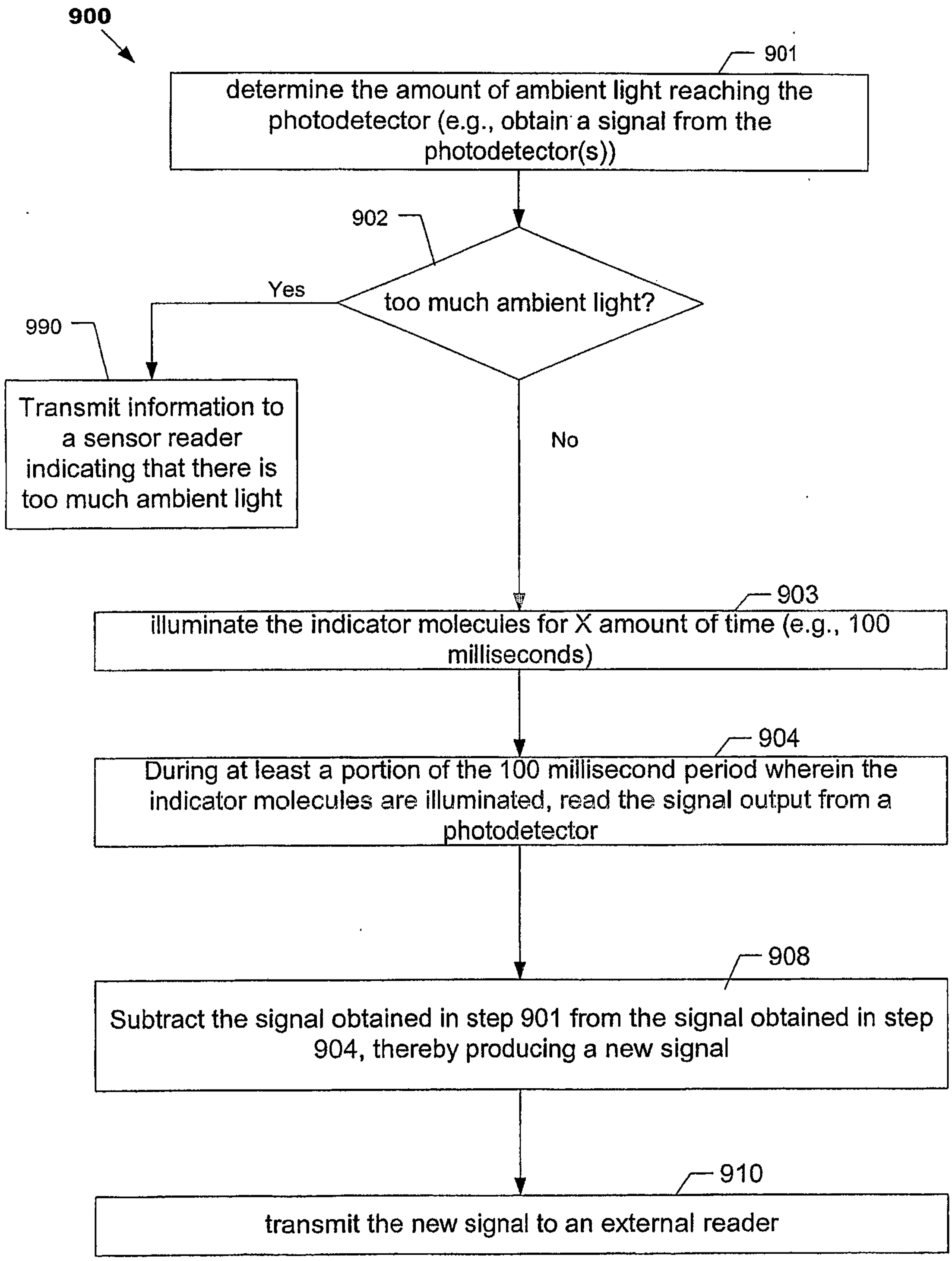
900
901
determine the amount of ambient light reaching the photodetector (e.g., obtain a signal from the photodetector(s))
902
too much ambient light?
Yes
No
990
Transmit information to a sensor reader indicating that there is too much ambient light
903
illuminate the indicator molecules for X amount of time (e.g., 100 milliseconds)
904
During at least a portion of the 100 millisecond period wherein the indicator molecules are illuminated, read the signal output from a photodetector
908
Subtract the signal obtained in step 901 from the signal obtained in step 904, thereby producing a new signal
910
transmit the new signal to an external reader

FIG. 9

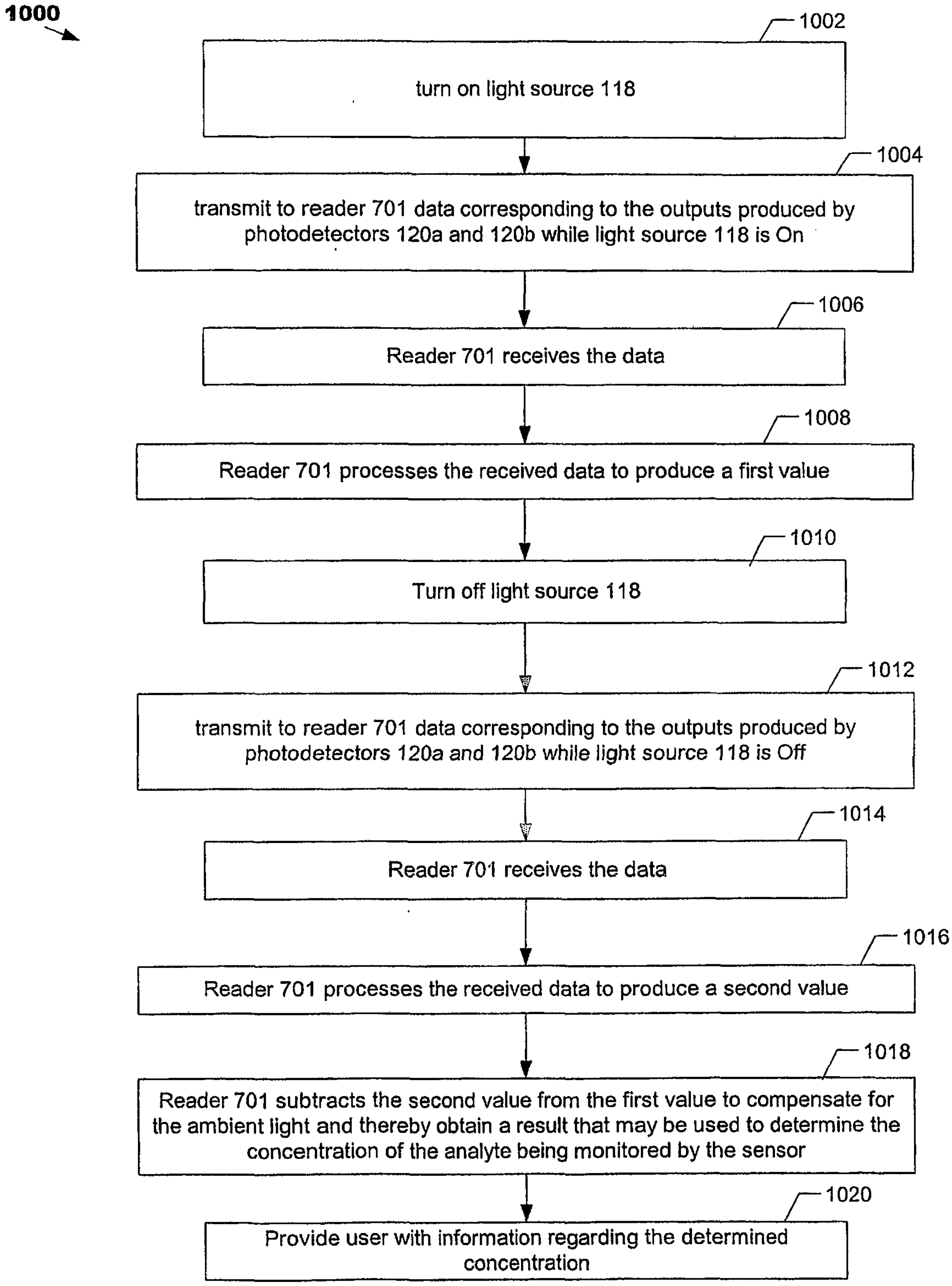
1000
1002
turn on light source 118
1004
transmit to reader 701 data corresponding to the outputs produced by photodetectors 120a and 120b while light source 118 is On
1006
Reader 701 receives the data
1008
Reader 701 processes the received data to produce a first value
1010
Turn off light source 118
1012
transmit to reader 701 data corresponding to the outputs produced by photodetectors 120a and 120b while light source 118 is Off
1014
Reader 701 receives the data
1016
Reader 701 processes the received data to produce a second value
1018
Reader 701 subtracts the second value from the first value to compensate for the ambient light and thereby obtain a result that may be used to determine the concentration of the analyte being monitored by the sensor
1020
Provide user with information regarding the determined concentration

FIG. 10

REFERENCES CITED IN THE DESCRIPTION

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- US 2002026108 A **[0004]**
- WO 0224048 A **[0005]**
- US 2002016535 A **[0006]**
- US 6201980 B **[0007]**
- US 6400974 B **[0017]**

patsnap

专利名称(译)	用于衰减环境光对光学传感器的影响的系统和方法		
公开(公告)号	EP1620714B1	公开(公告)日	2014-03-12
申请号	EP2004759497	申请日	2004-04-14
[标]申请(专利权)人(译)	医药及科学传感器公司		
申请(专利权)人(译)	医学和科学传感器公司		
当前申请(专利权)人(译)	SENSEONICS注册成立		
[标]发明人	COLVIN ARTHUR EARL JR ZERWEKH PAUL SAMUEL LESHO JEFFERY C LYNN ROBERT WILLIAM LORENZ CARRIE R OCONNOR CASEY J WALTERS STEVEN J		
发明人	COLVIN, ARTHUR, EARL, JR. ZERWEKH, PAUL, SAMUEL LESHO, JEFFERY, C. LYNN, ROBERT WILLIAM LORENZ, CARRIE, R. O'CONNOR, CASEY, J. WALTERS, STEVEN, J.		
IPC分类号	G01N21/64 A61B5/00 H05K1/02 H05K1/03 H05K1/16 H05K3/40		
CPC分类号	A61B5/14556 A61B5/0031 A61B5/14532 A61B5/1459 A61B5/681 G01N21/6428 G01N21/645 G01N2201/1244 H05K1/0306 H05K1/165 H05K3/403 H05K2201/086 H05K2201/09972 H05K2201 /10106		
优先权	60/462695 2003-04-15 US		
其他公开文献	EP1620714A2		
外部链接	Espacenet		

摘要(译)

本发明提供了用于衰减环境光对光学传感器的影响以及用于定量测量和补偿环境光的系统和方法。

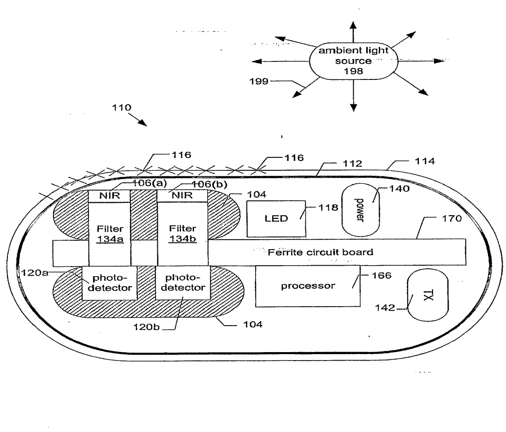

FIG. 1