(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 194 842 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
08.04.2015 Bulletin 2015/15

(21) Application number: **08807776.3**

(22) Date of filing: **24.09.2008**

(51) Int Cl.:
A61B 5/1455 *(2006.01)* ***A61B 5/00*** *(2006.01)*

(86) International application number:
PCT/IB2008/053874

(87) International publication number:
WO 2009/040740 (02.04.2009 Gazette 2009/14)

(54) **BLOOD OXIMETER**

BLUTOXYMETER

OXYMÈTRE SANGUIN

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR

(30) Priority: **27.09.2007 EP 07117427**

(43) Date of publication of application:
16.06.2010 Bulletin 2010/24

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Description

FIELD OF THE INVENTION

[0001] The invention relates to the field of blood oximeters and the measurement of oxygenation of blood flowing in living tissue.

BACKGROUND OF THE INVENTION

[0002] Blood oximeters, especially pulse oximeters are widely used for measuring oxygenation of blood of a patient since they provide a simple non-invasive method for monitoring the percentage of hemoglobin which is saturated with oxygen. Continuous monitoring of oxygen saturation via pulse oximetry is a standard of care for use in operating rooms, post anesthesia care units, critical care units, emergency departments etc.

[0003] A pulse oximeter typically comprises two small light-emitting diodes that emit light of different wavelenghts, typically in the red and the infrared part of the spectrum, respectively. The part of the emitted light transmitted through or reflected by tissue of a part of the patient's body, typically a fingertip or an ear lobe, is collected with a photodiode. Since absorption of these different wavelengths differs between oxyhemoglobin and its deoxygenated form, from the ratio of the collected red and infrared light, respectively, the percentage of hemoglobin which is saturated with oxygen can be determined. Such a pulse oximeter is known from US 5,595,176.

[0004] WO 2006/126152 A1 discloses a glucose sensor for the non-invasive measurement of glucose concentration in a live subject. The system comprises light emitting diodes and photodiodes for measuring the concentration of haemoglobin and oxygenated haemoglobin in the blood of a live tissue, a laser for generating a measurement beam and irradiating therewith a portion of said tissue, detector means for collecting measuring beam radiation reflected by said live subject, and means for determining from said measuring beam radiation blood flow velocity in respect of said live tissue. The means for determining blood flow velocity comprise self-mixing interferometry. WO 98/15224 discloses an optical sensor for measuring the oxygenation of flowing blood in living tissue. To reduce artefacts due to motion of the live tissue, the optical sensor is adapted to be placed on a nail and has a low mass.

[0005] It is an essential feature of conventional pulse oximeters that they rely on the pulsed part of the collected signal in order to discriminate the pulsating blood flow from the static tissue. Accordingly, pulse oximetry performs pure at low blood perfusion. Further, involuntary patient movements can be cumbersome for such measurements leading to poor measuring accuracy or defective measurement results.

SUMMARY OF THE INVENTION

[0006] It is an object of the invention to provide such a blood oximeter that performs well at low perfusion and which further allows for reliable measurements.

[0007] This object is achieved by a blood oximeter for measuring the oxygenation and at least one other parameter of flowing blood in living tissue, comprising:

- two light sources emitting light of different wavelengths into the tissue, wherein at least one of the light sources is a laser with a laser cavity emitting a laser beam, the laser being adapted to allow a part of the laser beam which is scattered by the tissue to re-enter into the laser cavity;
- a laser beam sensor for measuring the light emitted from the laser, the laser beam sensor, thus, obtaining a signal which varies in accordance with the self-mixing interferometric effect between the original laser beam and the scattered laser beam;
- a light detector for detecting a transmitted and/or reflected part of the light emitted into the tissue;
- a motion detector for detecting a motion of the irradiated tissue on the basis of the signal of the laser beam sensor and the signal of the light detector; and
- a motion processing unit for rejecting a measurement due to detected motions of the tissue or for correcting a measurement based on detected motions of the tissue.

[0008] Accordingly, it is an important feature of the invention that at least one light detector of the blood oximeter is designed as a laser which is adapted for self-mixing interferometry (SMI). This means that light emitted from the laser and scattered by the tissue is allowed to re-enter into the laser cavity. The interference between the light reflected back into the laser cavity and the light already present in the laser cavity causes power fluctuations in the laser. These power fluctuations are measurable with the laser beam sensor since the light that re-enters the laser cavity is reflected back from moving objects like moving blood cells, and, thus, its frequency is Doppler shifted. As a consequence, the power fluctuations in the laser cavity are determined by the Doppler frequency. Accordingly, the velocity of moving blood cells

can be measured with the use of the known Doppler formula that connects the frequency shift and the velocity. Thus, the invention provides for the possibility of blood oximetry and laser velocimetry in one single device having multiple advantages as set out in the following.

[0009] Further, a light detector for detecting a transmitted and/or reflected part of the light emitted into the tissue is provided. This light detector allows for conventional pulse oximetry.

[0010] In addition, a motion detector is provided for detecting a motion of the irradiated tissue on the basis of the signal of the laser beam sensor and the signal of the light detector. Still further, a motion processing unit is provided for rejecting a measurement due to detected motions of the tissue or for correcting a measurement based on detected motions of the tissue. This means that it is made use of the two different signals received by the light detector and the laser beam sensor, respectively, in order to eliminate or at least detect artifacts which originate from relative movements of the irradiated tissue relative to the laser and not from the blood flow itself. If too much movement of the tissue relative to the laser is detected the measurement is rejected and it can be indicated that the measurement has to be repeated. Further, it is also possible to correct such a measurement which means that reliable results are obtained though the tissue is moved relative to the laser.

[0011] In general, the laser beam can be directly irradiated onto the tissue without any further optical components. However, according to a preferred embodiment of the invention, a lens is provided for illuminating the laser beam into the tissue through this lens. For this lens, different focal lengths can be used. However, according to a further preferred embodiment of the invention, the focal length of the lens for illuminating the laser beam into the tissue is equal or less than 2 mm. This way, the reflected part of the light is collected and, thus, more light can re-enter into the laser cavity. Accordingly, the signal from the laser beam sensor shows a better S/N-ratio.

[0012] Generally, in operation of the blood oximeter, the illuminated tissue can be held at a distance from the laser and/or from the lens. This means that an air gap would be provided between the laser source and the tissue. However, according to a preferred embodiment of the invention, the lens is adapted to directly contact the illuminated tissue. This has the advantage that movements of the tissue relative to the laser can be avoided or at least minimized. Accordingly, Doppler shift effects due to tissue movement can be reduced.

[0013] The blood oximeter can be operated continuously. However, according to a preferred embodiment of the invention, a pulse controller is provided that allows for a pulsed operation of the laser. Especially, this pulse controller can be adapted for operating the laser during a measuring time of 20 ms or less at an operation frequency of approximately 1 Hz. This allows for an operation in a low power regime which is advantageous with respect to the kind of power supply used, especially in the case of the blood oximeter as a portable device.

[0014] In general, the blood oximeter does not have to comprise any further facilities. However, according to a preferred embodiment of the invention, a force actuator is provided for pressing the laser against the illuminated tissue with a predefined pressure. This provides for the possibility of additionally measuring the blood pressure as set out in more detail further below.

[0015] Generally, the pressure of the force actuator can be a predefined constant pressure. However, according to a preferred embodiment of the invention, a pressure controller is provided for applying a predefined pressure which changes in time. This allows for accurate blood pressure measurements.

[0016] As set out above, it might be sufficient if only one of the light sources of the blood oximeter is designed as a laser. However, according to a preferred embodiment of the invention, both light sources are designed as a laser with a corresponding laser beam sensor, respectively. This provides for further possibilities as described in the following.

[0017] In general, the blood oximeter is adapted to provide a Sp02 value based on the ratio of the intensities of the light received by the light detector and transmitted and/or reflected from the first light source and the second light source, respectively. However, according to a preferred embodiment of the invention, a S02 unit is provided for determining and indicating a SO2 value based on the signals of both of the laser beam sensors. This means that according to this preferred embodiment of the invention, there is not only the possibility to measure and indicate the oxygenation of blood under normal circumstances with sufficient perfusion but also at low perfusion when pulsation of the blood flow due to the heart beat is minimal. Further, this preferred embodiment of the invention also allows for a quick start of the oximeter because the S02 measurement can be done in the first measurement cycle which can be as short as 20 ms or less.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

[0019] In the drawings:

Fig. 1 is a schematic view of a blood oximeter according to a first preferred embodiment of the invention;

Fig. 2a is a graph of the Doppler shift spectrum for the infrared laser at two moments in time, i.e. during pulsation of the artery and for non-pulsating artery;

Fig. 2b a graph of the pulsating part of the spectrum with its changes in time;
Fig. 3 spectra taken with the pulse oximetry photodiode and taken with the monitoring photodiode of the red laser are shown;
Fig. 4 is a schematic view of a blood oximeter according to a second preferred embodiment of the invention;
Fig. 5 shows the variation of the monitoring photodiode spectrum with the cardiac cycle;
Fig. 6a shows the measured heart beat when a fingertip is pressed hard;
Fig. 6b shows the measured heart beat when the fingertip is pressed softly; and
Fig. 7 shows diastolic and systolic transitions, respectively.

DETAILED DESCRIPTION OF EMBODIMENTS

[0020] From Figure 1 a schematic view of a blood oximeter according to a first preferred embodiment of the invention can be seen. This blood oximeter is used on a fingertip 1 of a patient and comprises a red laser 2 emitting light in the red part of the light spectrum, an infrared laser 3 emitting light in the infrared part of the light spectrum, and a pulse oximetry photodiode 4. The red laser 2 and the infrared laser 3 are each provided with a lens 5, 6 and with a monitoring photodiode 7, 8, respectively. Both lenses 5, 6 have a focal length of 1.5 mm and are provided between the fingertip 1, and the red laser 2 and the infrared laser 3, respectively. Since the fingertip 1 directly contacts the lenses 5, 6, relative movement of the fingertip 1 with respect to the lasers 2, 3 is minimized. Further, monitoring photodiodes 7, 8 for the red laser 2 and the infrared laser 3, respectively, are provided for measuring the light emitted from each laser 2, 3.

[0021] The blood oximeter according to the first preferred embodiment shown in Figure 1 is operated as follows: Since the red laser 2 operates at a wavelength of 660 mm and the infrared laser 3 operates at a wavelength of 950 mm, the signals received by the pulse oximetry photodiode 4 can be used in a conventional and well known way in order to determine the oxygenation of blood by pulse oximetry. Further, since the red laser 2 and the infrared laser 3 both are adapted to allow a part of the laser beam which is respectively emitted by these lasers 2, 3, to re-enter into the respective laser cavity, self-mixing interferometric effects are achieved in the lasers 2, 3. This means that due to the part of the laser beam that re-enters into the cavity of the respective laser 2, 3, power fluctuations of the lasers 2, 3 occur. These power fluctuations are observed with the help of monitoring photodiodes 7, 8 which measure the light emitted from the respective laser 2, 3.

[0022] As already stated above, power fluctuations of the lasers 2, 3 are due to the fact that the part of the laser beam that re-enters a respective laser 2, 3 is Doppler shifted because of the moving red blood cells from which the light is reflected. The Doppler shift is related to the velocity of the red blood cells according to the Doppler formula:.

$$\Delta f = \frac{2\mathrm{v}}{\lambda} \qquad (1)$$

[0023] Therein, Δf is the Doppler shift, v is the velocity of the red blood cells and λ is the irradiated wavelength.

[0024] From Figure 2a the Doppler shift spectrum for the infrared laser 3 can be seen at two moments in time, i. e. during pulsation of the artery and for non-pulsating artery. This means that the Doppler shift spectrum consists of two parts: A pulsating part (p) and a non-pulsating part (np). The pulsating part is related to the part of the blood moving in the artery. Here, the amount of blood that flows changes with the pulse as well as the distribution of velocities. As it is known, the velocity of blood in veins is constant and does not "feel" the pulse. The veins, thus, reflect in the non-pulsating part of the spectrum. From Figure 2b, the pulsating part of the spectrum is shown with its changes in time. This reflects the heart beat.

[0025] According to the first preferred embodiment described here, this Doppler shift information is combined with a conventional blood oximeter. The amount of laser light scattered by a single red blood cell does not significantly depend on the concentration of oxygen. However, the amount of light absorbed is strongly dependent on the oxygen concentration. This is the principle of conventional pulse oximetry: The more oxygen is in the artery the more infrared light is absorbed and the less red light is absorbed.

[0026] The Doppler spectrum can be analyzed in a manner similar to the usual pulse oximetry. For example, the energy of the spectrum in the pulsating area for the red laser 2 can be considered:

$$S_{red}\left(\omega_1, \omega_2, t\right) \qquad (2)$$

[0027] This value changes in time according to the pulse of the patient. Thus, a part of this value represents light

scattered by the blood flowing in the artery which can be better investigated taking into account the corresponding frequency range which can then be related to velocities:

$$S_{red}(\omega_1,\omega_2,t)=S_{red}^{const}(\omega_1,\omega_2)+S_{red}^{artery}(\omega_1,\omega_2,t) \quad (3)$$

[0028] If only single scattering events are considered it can be assumed to some extend that the component that is reflected by the artery is proportional to the number of red cells which are responsible for scattering, and, thus, proportional to the amount of blood pulsating in the artery B(t):

$$S_{red}^{artery}(\omega_1,\omega_2,t)\approx B(t)f_{red}(\omega_1,\omega_2,c_A,c_V) \quad (4)$$

[0029] The second term f_{red} is constant in time and depends on the oxygen concentration in the artery c_A and in veins c_V, respectively, as well as other local factors such as the distribution of blood cell velocities. It directly quantifies the amount of light in this frequency range (ω_1, ω_2) that was absorbed.

[0030] If the changes in the pulse are measured, this yields:

$$\begin{aligned}\Delta S_{red}(\omega_1,\omega_2,t)&\approx\Delta B(t)f_{red}(\omega_1,\omega_2,c_A,c_V)=\\&=\Delta S_{red}^{artery}(\omega_1,\omega_2,t)=\Delta B(t)f_{red}(\omega_1,\omega_2,c_A)\end{aligned} \quad (5)$$

[0031] As usual in pulse oximetry, only arterial variations can be seen. In addition, this is only related to blood scattered by the artery if simplified to single scattering events.

[0032] The same can be written for the infrared laser 3, wherein the amount of blood pulsating B(t) is the same:

$$\Delta S_{ired}(\omega_1,\omega_2,t)\approx\Delta B(t)f_{ired}(\omega_1,\omega_2,c_A) \quad (6)$$

[0033] By dividing the two, the term B(t) that gives the amount of pulsating blood can be removed:

$$\frac{\Delta S_{red}(\omega_1,\omega_2,t)}{\Delta S_{ired}(\omega_1,\omega_2,t)}=f(\omega_1,\omega_2,c_A) \quad (7)$$

[0034] Further, corrections for the amount of light given by the lasers 2, 3 and which may fluctuate in time can be done:

$$\frac{\Delta S_{red}(\omega_1,\omega_2,t)}{\Delta S_{ired}(\omega_1,\omega_2,t)}\frac{I_{ir}^{DC}}{I_{r}^{DC}}=f(\omega_1,\omega_2,c_A) \quad (8)$$

[0035] If not only single scattering events are considered, a function $f(\omega_1, \omega_2, \omega_A, \omega_V)$ has to be used which can be determined by calibration. After calibration, thus, a relation between the oxygen concentration in artery c_A and the oxygen concentration in veins c_V can be measured by comparing the red and the infrared spectra.

[0036] In the case of going beyond single scattering events, the two terms, corresponding to the veins and the artery, respectively, have to be disentangled. More degrees of freedom may be used, such as different frequency ranges. The distribution of velocities in veins and artery are different and they will be different in different parts of the Doppler shift spectra. In addition, the terms that do not pulsate can be used. Such terms are more related to blood flowing in the veins which does not pulsate. Using all this information it is possible to determine the oxygen in the artery and in the veins,

respectively, more accurately.

[0037] Above terms only reflect pulse changes. However, the method can be extended to measurements at low perfusion where practically no pulse is present. In such a case it has to be relied on the whole spectrum which is time independent because there is no pulse:

$$\frac{S_{red}(\omega_1,\omega_2)}{S_{ired}(\omega_1,\omega_2)}\frac{I_{ir}^{DC}}{I_r^{DC}} = f(\omega_1,\omega_2,c_A,c_v) \qquad (9)$$

[0038] If the whole spectrum is integrated, an average concentration in blood is received. This is, thus, a SO2 value. This method can also be used in cases when the pulsating component of the blood is intentionally removed. In such cases, when there is no change in the blood volume, the Doppler information given by formula (9) can still be used to get the oxygen concentration of blood.

[0039] Further, this method can also be used for low power consumption and/or a quick start of the S02 oximeter. This is possible because the measurement is done in a very short time, i. e. about 10-20 ms, and no complete pulse has to be monitored. In order to work in the low power regime, the lasers 2, 3 are only switched on for 10-20 ms per second in the case of S02 measurement. Typical consumption of the lasers 2, 3 is about 1 mW in cw-mode. Thus, few tenths of microseconds can be achieved in pulsating mode. This is also why a quick start is possible since it is not necessary to wait for multiple pulses.

[0040] As can be seen from Figure 1, the blood oximeter according to the first preferred embodiment of the invention is provided with a pulse controller 9 for operating the blood oximeter in a pulsed mode, and with a S02 unit 10 for determining and indicating an S02 value as described above. Further, the blood oximeter according to the first preferred embodiment comprises a motion detector 11 and a motion processing unit 12 which are operated as set out in the following:

> One of the main problems of conventional blood oximeters are motion artifacts during involuntary patient movement. Such artifacts occur when a patient's movements cause the blood oximeter to incorrectly interpret the movements as a pulse signal or when the motion artifact prevents accurate detection of the patient's real pulse signal. This may lead to increasing false alarms and erroneous measurements.

[0041] With the blood oximeter according to the first embodiment of the invention, both light sources are designed as lasers 2, 3 adapted for self-mixing interferometry. This provides additional information related to the movement of the blood oximeter with respect to the irradiated tissue, as from a fingertip 1 of the patient. This information can be used to correct the artifacts present in the pulse oximetry photodiode 4 or simply to reject the data as unreliable due to the detected movements.

[0042] From Figure 3 spectra taken with the pulse oximetry photodiode 4 and taken with the monitoring photodiode 7 of the red laser 2, respectively, are shown. The signals received with monitoring photodiode 7 are shown for low frequencies and for high frequencies, respectively, and in both cases for energy and third momentum thereof.

[0043] As can be seen from the spectrum taken with the pulse oximetry photodiode 4, at time 20 s movements start and, thus, no more heart beat can be observed in the signal of the pulse oximetry photodiode 4. In order to avoid any misinterpretation of this signal from the pulse oximetry photodiode 4, the motion detector 10 is fed with the signal from the monitoring photodiode 7. As can be seen from Figure 3, especially the spectra from the monitoring photodiode 7 for low frequencies show a prominent signal change at time 20 s (encircled). Accordingly, by monitoring the signal from the monitoring photodiode 7 movements can be detected and, thus, the measurement can be rejected by motion processing unit 12.

[0044] From Figure 4 a blood oximeter according a second preferred embodiment of the invention can be seen. Further to the blood oximeter according to the first preferred embodiment of the invention, here, a force actuator 13 for pressing the lasers 2, 3 against the illuminated part of the fingertip 1, and a pressure controller 14 for applying a predefined pressure changing in time are provided. This provides for the possibility of simultaneously measuring the blood pressure as set out in the following.

[0045] The monitoring photodiodes 7, 8 measure the velocities of the red blood cells inside the fingertip 1. In order to see this information, measured data is split into intervals of 10 ms. The frequency spectrum of each of these intervals is calculated. A number of these spectra are shown in Figure 5 with the relative time at which they were measured, all for the same force.

[0046] Figure 5 shows that the spectrum "dances" up and down between frequencies of about 10 kHz to 40 kHz. This is the effect of the cardiac cycle: The frequency of this variation of the spectrum is the heart rate. The measured velocities can be obtained using Doppler shift formula, and they correspond to the expected blood velocities at a depth corresponding

to the focal lengths of the lenses 5, 6, which are 1.5 mm according to the preferred embodiments of the invention.

[0047] The signal can be plotted as a function of time if the spectrum is integrated in a certain frequency range and the energy is plotted in that spectrum as a function of time. The resulting signal shows the heart beat and is dependent on the force applied as can be seen from Figure 6.

[0048] During the blood pressure measurements the force with which the force actuator 13 presses the lasers 2, 3 against the fingertip 1 is increased by the pressure controller 14, and for each value of the force a certain number of spectra are measured. When the applied pressure is lower than the diastolic pressure the blood flows during the entire cardiac cycle. When the pressure on the fingertip 1 is increased to a value higher than the diastolic pressure, the capillaries collapsed and blood stops flowing.

[0049] To measure the blood pressure, the dominant frequencies in the spectrum of one of the monitoring photodiodes 7, 8 can be determined. The "dancing" of the spectrum shows a frequency range of approximately 10 kHz to 40 kHz. When the force on the fingertip 1 is increased, the active part of the spectrum shifts to lower frequencies. This shift continues until the frequencies between 1 kHz and 2 kHz are the most active frequencies. This shift in active frequencies is also an indication of the diastolic and systolic transitions.

[0050] A method for evaluating the most active frequencies is the following:

1. For every cardiac cycle all spectra taken with monitoring photodiode 7 are calculated.
2. For every frequency, the maximum and the minimum of all these spectra are evaluated.
3. For every frequency, the ratio of this maximum and minimum is calculated.
4. The frequency at which this ratio is largest is the most active frequency.
5. This dominant frequency is evaluated for every cardiac cycle and plotted against the force applied by the force actuator 13.

[0051] An example of the resulting plot with the transition from high dominant frequency to low dominant frequency is shown in Figure 7. This transition was measured by slowly increasing the force on the fingertip 1 over a duration of one minute. As can be seen, the dominant frequency decreases when the force increases. The two transition points on the finger reflector systolic and diastolic transition, respectively.

[0052] As a result, compared with conventional blood oximeters, the invention allows for the following advantages:

The blood oximeter is more robust against environment light because it does not rely on the absolute intensity of the light as in conventional pulse oximetry.

[0053] The oxygen content in both veins and artery can be measured relying on different Doppler shift frequency bands and on the pulsating component.

[0054] Doppler shift oximetry provides an average concentration of oxygen in blood, i. e. both in veins and artery, at low perfusion. Even though a pulse may be hardly present in this case, the signal coming from the moving blood is present and the amount of light absorbed by the tissue is dependent on the oxygen concentration.

[0055] The blood oximeter according can be operated in a low power regime because it only needs a few tenths of a second of measurement and further can be operated in a pulsed mode. Accordingly, the device may have a quicker start, too.

[0056] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A blood oximeter for measuring the oxygenation and at least one other parameter of flowing blood in living tissue, comprising:

   two light sources (2, 3) emitting light of different wavelengths into the tissue, wherein at least one of the light sources (2, 3) is a laser with a laser cavity emitting a laser beam, the laser being adapted to allow a part of the laser beam which is scattered by the tissue to re-enter into the laser cavity; and

a laser beam sensor (7, 8) for measuring the light emitted from the laser, the laser beam sensor (7, 8), thus, obtaining a signal which varies in accordance with a self-mixing interferometric effect between the original laser beam and the scattered laser beam;
a light detector (4) for detecting a transmitted and/or reflected part of the light emitted into the tissue;
characterised in that the blood oximeter further comprises: a motion detector (11) for detecting a motion of the irradiated tissue on the basis of the signal of the laser beam sensor (7, 8) and the signal of the light detector (4); and
a motion processing unit (12) for rejecting a measurement due to detected motions of the tissue or for correcting a measurement based on detected motions of the tissue.

2. The blood oximeter according to claim 1, wherein a lens (5, 6) is provided for illuminating the laser beam into the tissue through the lens (5, 6), the lens (5, 6) having preferably a focal length of equal or less than 2 mm.

3. The blood oximeter according to claim 2, wherein the lens (5, 6) is adapted to directly contact the illuminated tissue.

4. The blood oximeter according to any of claims 1 to 3, wherein a pulse controller (9) for a pulsed operation of the laser is provided.

5. The blood oximeter according to any of claims 1 to 4, wherein a force actuator (13) is provided for pressing the laser against the illuminated tissue with a predefined pressure.

6. The blood oximeter according to claim 5, wherein a pressure controller (14) is provided for applying a predefined pressure changing in time.

7. The blood oximeter according to any of claims 1 to 6, wherein both light sources (2, 3) are designed as a laser with a laser beam sensor (7, 8), respectively.

8. The blood oximeter according to claim 7, wherein a S02 unit (10) is provided for determining and indicating an S02 value based on the signals of both of the laser beam sensors (7, 8).

Patentansprüche

1. Blutoximeter zum Messen der Sauerstoffsättigung und von mindestens einem weiteren Parameter des Blutflusses in lebendem Gewebe, wobei das Blutoximeter Folgendes umfasst:

zwei Lichtquellen (2, 3), die Licht unterschiedlicher Wellenlängen in das Gewebe emittieren, wobei mindestens eine der Lichtquellen (2, 3) ein Laser mit einem einen Laserstrahl emittierenden Laserhohlraum ist, wobei der Laser dafür ausgelegt ist, einen Teil des Laserstrahls, der durch das Gewebe gestreut wird, wieder in den Laserhohlraum eintreten zu lassen; und
einen Laserstrahlsensor (7, 8) zum Messen des aus dem Laser emittierten Lichts, wobei der Laserstrahlsensor (7, 8) somit ein Signal erlangt, das in Übereinstimmung mit einem selbstmischenden Interferometrieeffekt zwischen dem ursprünglichen Laserstrahl und dem gestreuten Laserstrahl variiert;
einen Lichtdetektor (4) zum Detektieren eines gesendeten und/oder reflektierten Teils des in das Gewebe emittierten Lichts;

dadurch gekennzeichnet, dass das Blutoximeter weiterhin Folgendes umfasst:

einen Bewegungsdetektor (11) zum Detektieren einer Bewegung des bestrahlten Gewebes auf der Basis des Signals des Laserstrahlsensors (7, 8) und des Signals des Lichtdetektors (4); und
eine Bewegungsverarbeitungseinheit (12) zum Zurückweisen einer Messung aufgrund der detektierten Gewebebewegungen oder zum Korrigieren einer Messung basierend auf detektierten Gewebebewegungen.

2. Blutoximeter nach Anspruch 1, wobei eine Linse (5, 6) zum Ausleuchten des Laserstrahls durch die Linse (5, 6) in das Gewebe hinein vorgesehen ist, wobei die Linse (5, 6) vorzugsweise eine Brennweite von gleich oder weniger als 2 mm hat.

3. Blutoximeter nach Anspruch 2, wobei die Linse (5, 6) für den direkten Kontakt mit dem ausgeleuchteten Gewebe

ausgelegt ist.

4. Blutoximeter nach einem der Ansprüche 1 bis 3, wobei eine Impulssteuereinheit (9) für einen gepulsten Betrieb des Lasers vorgesehen ist.

5. Blutoximeter nach einem der Ansprüche 1 bis 4, wobei ein Kraft-Aktuator (13) vorgesehen ist, um den Laser mit einem vorgegebenen Druck gegen das ausgeleuchtete Gewebe zu drücken.

6. Blutoximeter nach Anspruch 5, wobei eine Drucksteuereinheit (14) vorgesehen ist, um einen vorgegebenen Druck auszuüben, der sich im Zeitverlauf ändert.

7. Blutoximeter nach einem der Ansprüche 1 bis 6, wobei beide Lichtquellen (2, 3) als jeweils ein Laser mit einem Laserstrahlsensor (7, 8) konzipiert sind.

8. Blutoximeter nach Anspruch 7, wobei eine S02-Einheit (10) vorgesehen ist, um einen S02-Wert basierend auf den Signalen von beiden Laserstrahlsensoren (7, 8) zu ermitteln und anzugeben.

Revendications

1. Oxymètre sanguin pour mesurer l'oxygénation et au moins un autre paramètre de sang circulant dans un tissu vivant, comprenant :

   deux sources lumineuses (2, 3) émettant de la lumière de différentes longueurs d'onde dans le tissu, dans lequel au moins une des sources lumineuses (2, 3) est un laser avec un cavité laser émettant un faisceau laser, le laser étant adapté pour permettre à une partie du faisceau laser qui est diffusée par le tissu de repénétrer dans la cavité laser ; et
   un capteur de faisceau laser (7, 8) pour mesurer la lumière émise par le laser, le capteur de faisceau laser (7, 8) obtenant, ainsi, un signal qui varie conformément à un effet interférométrique d'automélange entre le faisceau laser original et le faisceau laser diffusé ;
   un détecteur de lumière (4) pour détecter une partie transmise et/ou réfléchie de la lumière émise dans le tissu ;
   caractérisé en ce que l'oxymètre sanguin comprend en outre ;

      un détecteur de mouvement (11) pour détecter un mouvement du tissu irradié sur base du signal du capteur de faisceau laser (7, 8) et du signal du détecteur de lumière (4) ; et
      une unité de traitement de mouvement (12) pour rejeter une mesure du fait de mouvements détectés du tissu ou pour corriger une mesure sur base des mouvements détectés du tissu.

2. Oxymètre sanguin selon la revendication 1, dans lequel une lentille (5, 6) est fournie pour éclairer le faisceau laser dans le tissu à travers la lentille (5, 6), la lentille (5, 6) possédant de préférence une longueur focale égale ou inférieure à 2 mm.

3. Oxymètre sanguin selon la revendication 2, dans lequel la lentille (5, 6) est adaptée pour venir directement en contact avec le tissu éclairé.

4. Oxymètre sanguin selon l'une quelconque des revendications 1 à 3, dans lequel un dispositif de commande d'impulsions (9) pour un fonctionnement pulsé du laser est fourni.

5. Oxymètre sanguin selon l'une quelconque des revendications 1 à 4, dans lequel un actionneur de force (13) est fourni pour presser le laser contre le tissu éclairé avec une pression prédéfinie.

6. Oxymètre sanguin selon la revendication 5, dans lequel un dispositif de commande de pression (14) est fourni pour appliquer une pression prédéfinie changeant dans le temps.

7. Oxymètre sanguin selon l'une quelconque des revendications 1 à 6, dans lequel l'une et l'autre des sources lumineuses (2, 3) sont conçues en tant que laser avec un capteur de faisceau laser (7, 8), respectivement.

8. Oxymètre sanguin selon la revendication 7, dans lequel une unité à S02 (10) est fournie pour déterminer et indiquer

une valeur de S02 sur base des signaux de l'un et l'autre des capteurs de faisceau laser (7, 8).

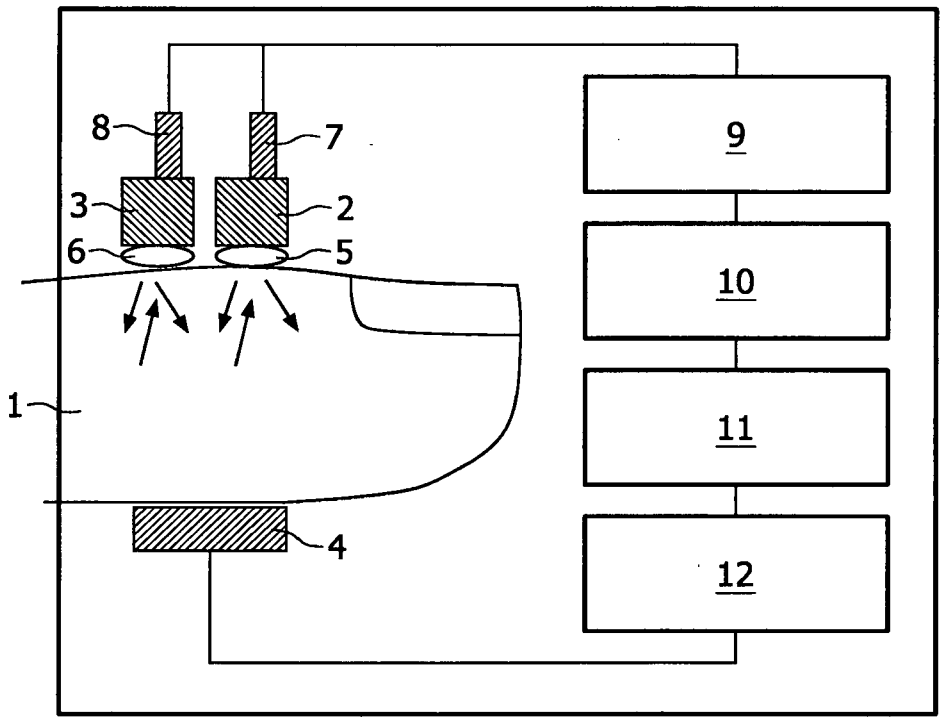

FIG. 1

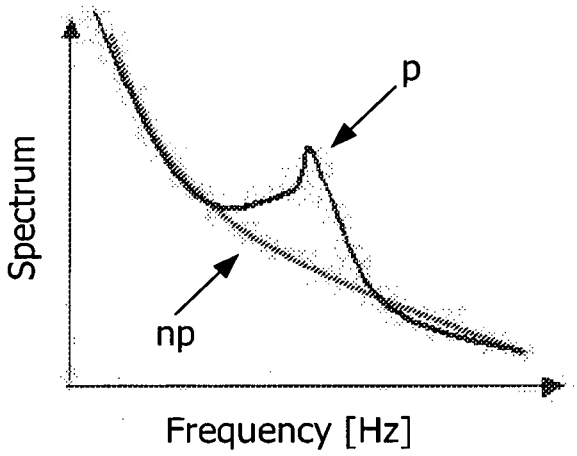

FIG. 2A

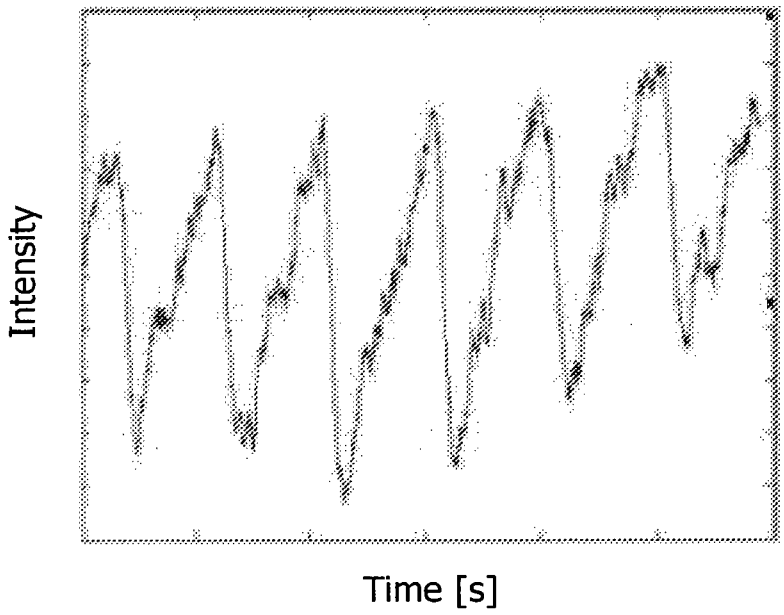

FIG. 2B

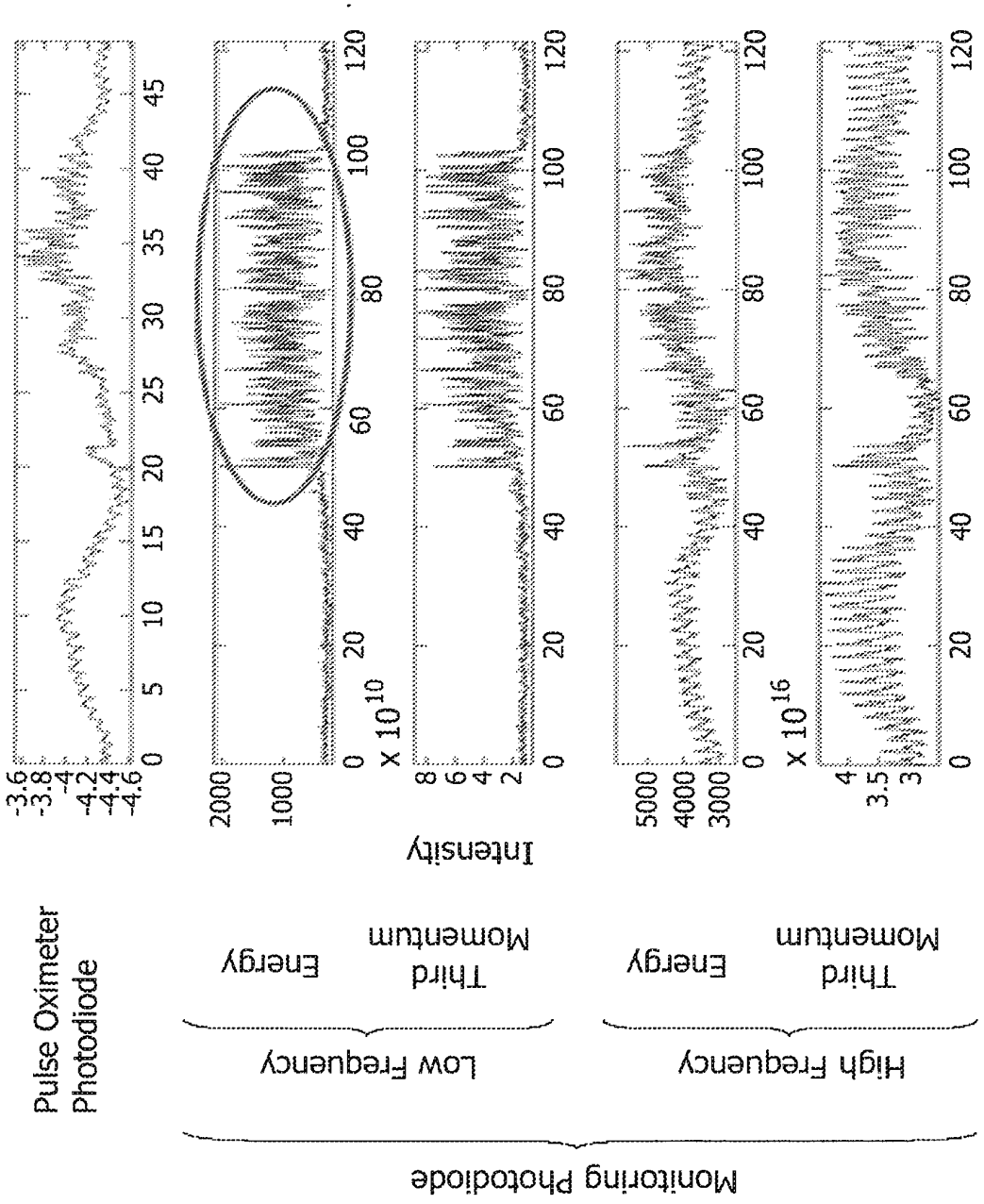
Pulse Oximeter Photodiode
Monitoring Photodiode
Low Frequency
High Frequency
Third Momentum
Energy
Third Momentum
Energy
Intensity
Time [s]

FIG. 3

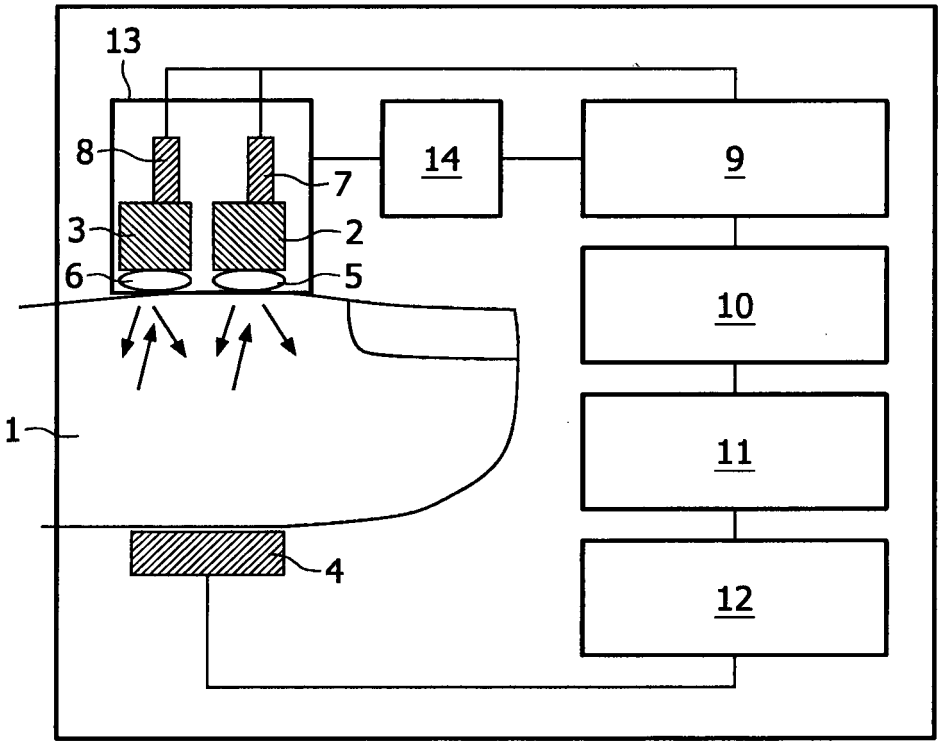

FIG. 4

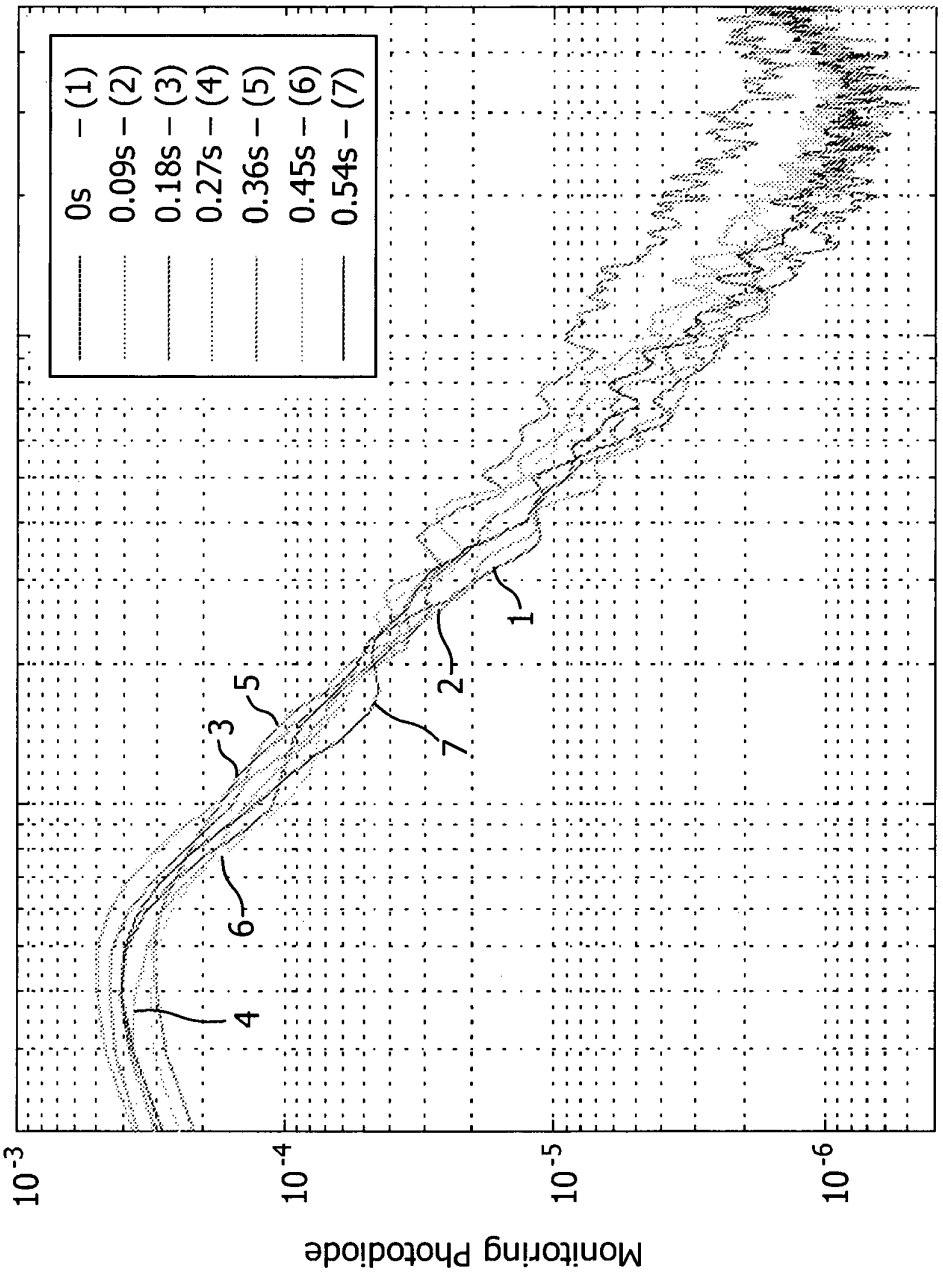
0s – (1)
0.09s – (2)
0.18s – (3)
0.27s – (4)
0.36s – (5)
0.45s – (6)
0.54s – (7)
1
2
3
4
5
6
7
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{3}
10^{4}
Monitoring Photodiode
Frequency [Hz]

FIG. 5

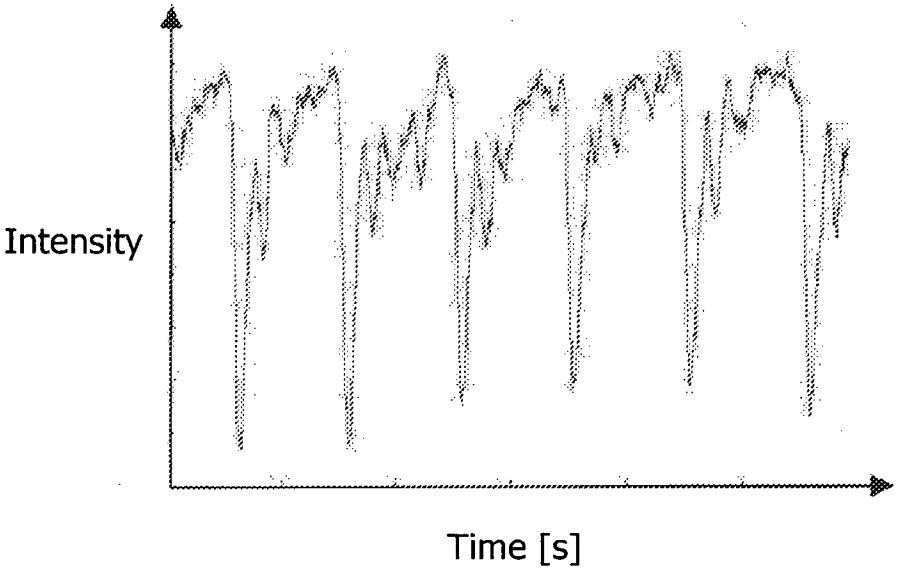

FIG. 6A

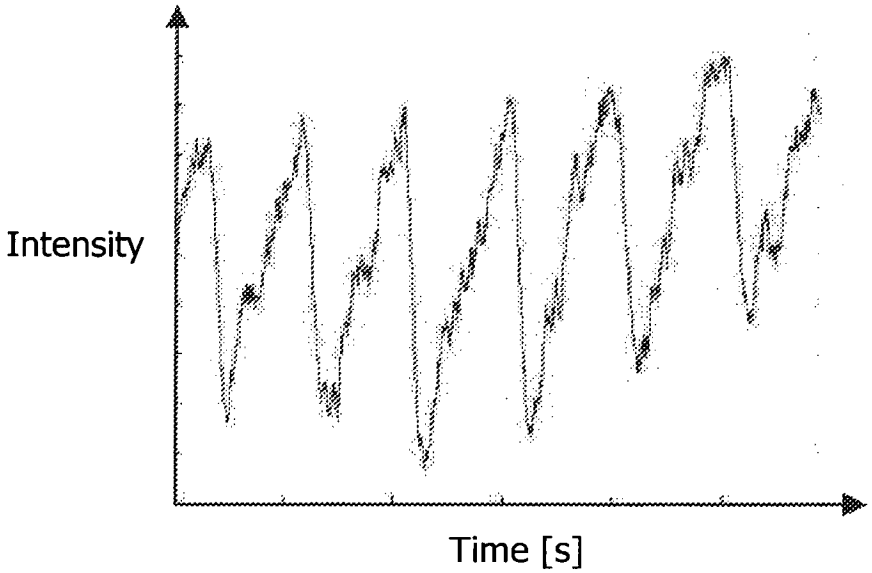

FIG. 6B

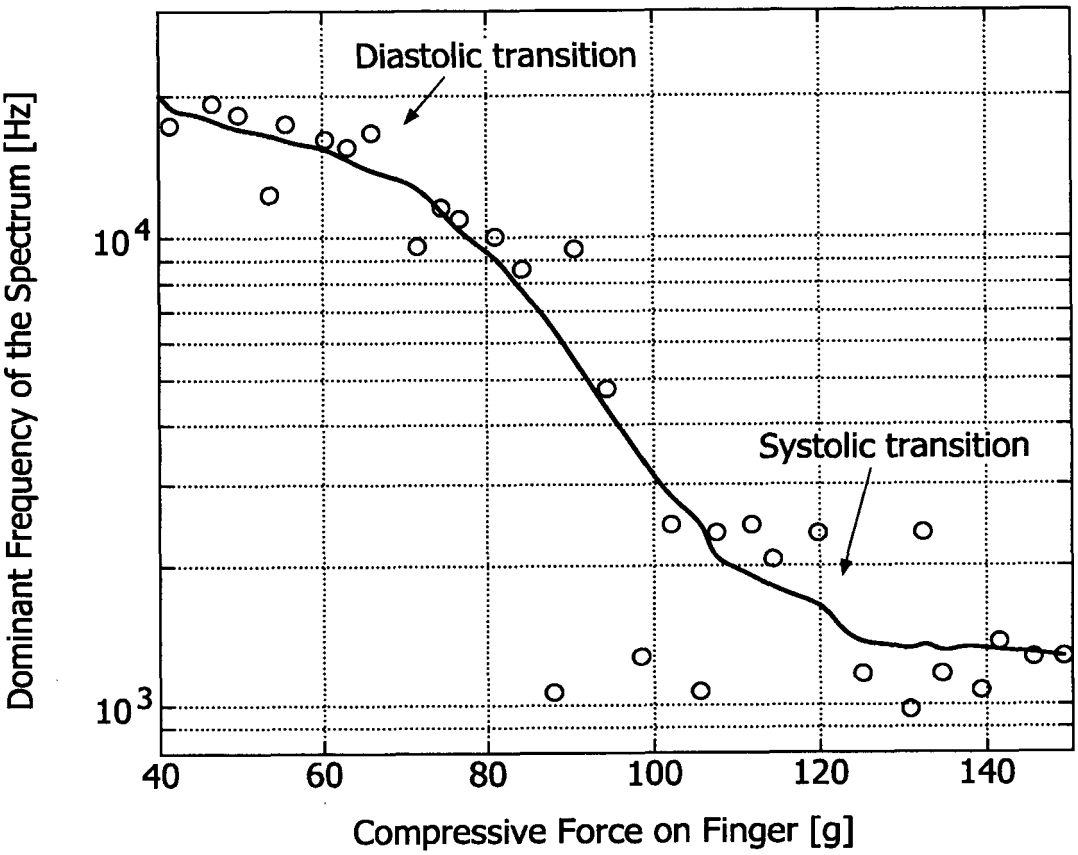
Diastolic transition
Systolic transition
Dominant Frequency of the Spectrum [Hz]
10^4
10^3
40
60
80
100
120
140
Compressive Force on Finger [g]

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5595176 A **[0003]**
- WO 2006126152 A1 **[0004]**
- WO 9815224 A **[0004]**

专利名称(译)	血氧计		
公开(公告)号	EP2194842B1	公开(公告)日	2015-04-08
申请号	EP2008807776	申请日	2008-09-24
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
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IPC分类号	A61B5/1455 A61B5/00		
CPC分类号	A61B5/14551 A61B5/721		
优先权	2007117427 2007-09-27 EP		
其他公开文献	EP2194842A1		
外部链接	Espacenet		

摘要(译)

血氧计技术领域本发明涉及一种血氧计，用于测量活组织中的血液的氧合作用和至少一个其他参数。根据本发明，血氧计包括两个将不同波长的光发射到组织中的光源（2,3），并且优选地是用于检测发射到组织中的光的透射和/或反射部分的光检测器（4），其中至少一个光源是具有发射激光束的激光腔的激光器，该激光器适于允许由组织散射的一部分激光束重新进入激光腔，并且其中激光器提供用于测量从激光器发射的光的光束传感器（7,8），激光束传感器（7,8）因此获得根据原始激光束和原始激光束之间的自混合干涉效应而变化的信号。散射激光束。因此，提供了这样的血氧计，其执行低灌注，并且还允许可靠的测量