US 20180000393A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2018/0000393 A1**

Hsieh et al. (43) **Pub. Date: Jan. 4, 2018**

(54) **MULTIPLE PHYSIOLOGICAL SIGNALS SENSING CHIP AND THE MULTIPLE PHYSIOLOGICAL SIGNALS SENSING METHOD THEREOF**

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(21) Appl. No.: **15/263,189**

(22) Filed: **Sep. 12, 2016**

(30) **Foreign Application Priority Data**

Jul. 4, 2016 (TW) 105121064

Publication Classification

(51) **Int. Cl.**

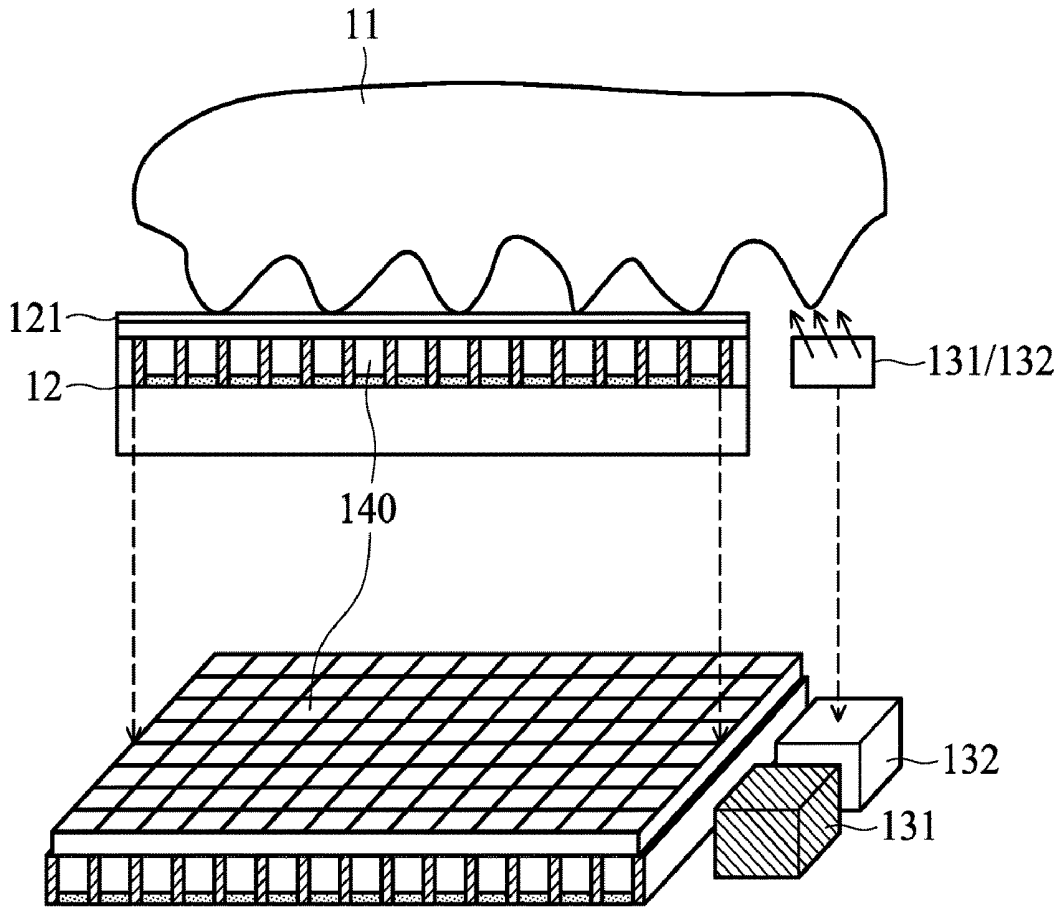
A61B 5/1455	(2006.01)
A61B 5/0205	(2006.01)
A61B 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 5/14552*** (2013.01); ***A61B 5/6826*** (2013.01); ***A61B 5/02055*** (2013.01); *A61B 2562/0238* (2013.01)

(57) **ABSTRACT**

A multiple physiological signals sensing chip is provided. The multiple physiological signals sensing chip includes a substrate, a first light-emitting diode, a second light-emitting diode, a sensing array, and a processing unit. The substrate includes a contact surface touched by a finger. The first and second light-emitting diodes respectively emit red light and infrared light to the finger. The sensing array senses the red light or the infrared light reflected or refracted from the finger to obtain first physiological sensing signals according to a first sensing period or senses the red light and the infrared light reflected or refracted from the finger to obtain second physiological sensing signals according to a second sensing period. The first sensing period is shorter than the second sensing period. The processing unit respectively processes the first and second physiological sensing signals to obtain spatial information and energy information corresponding to the finger.



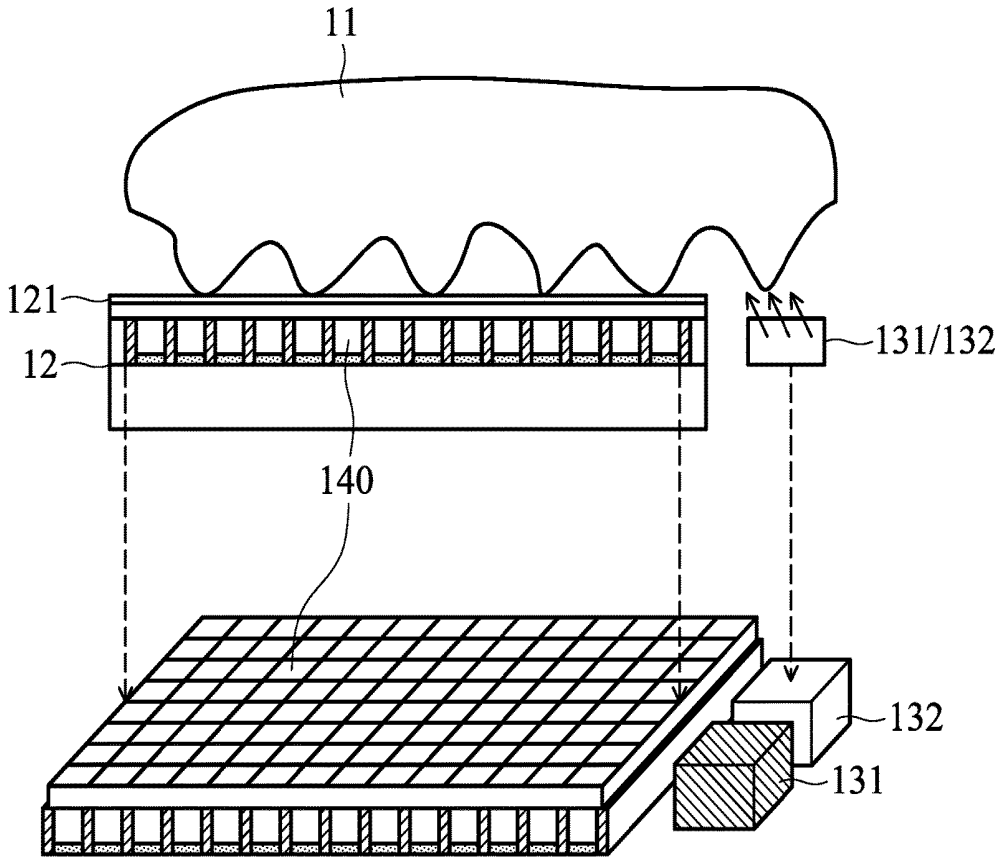


FIG. 1A

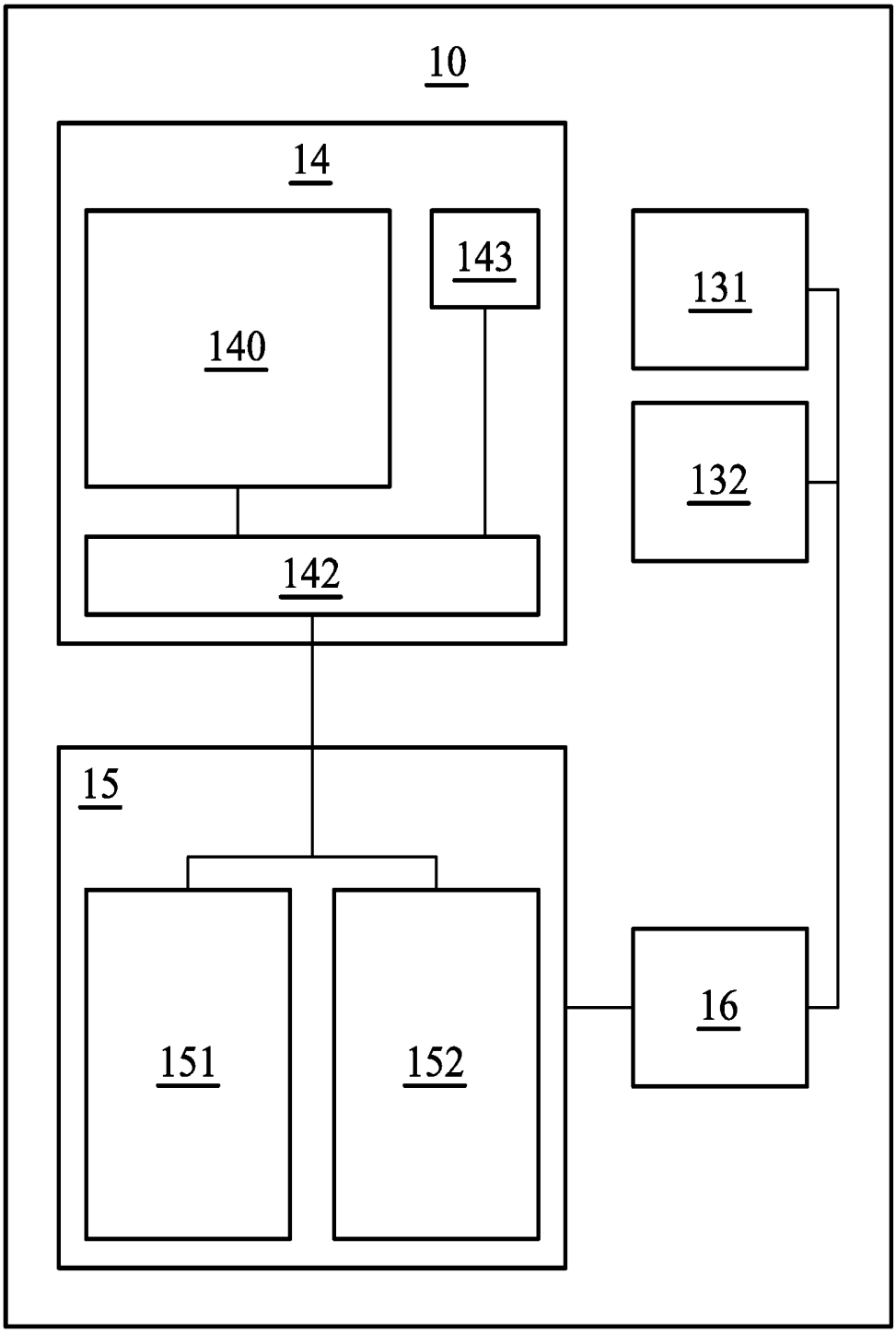


FIG. 1B

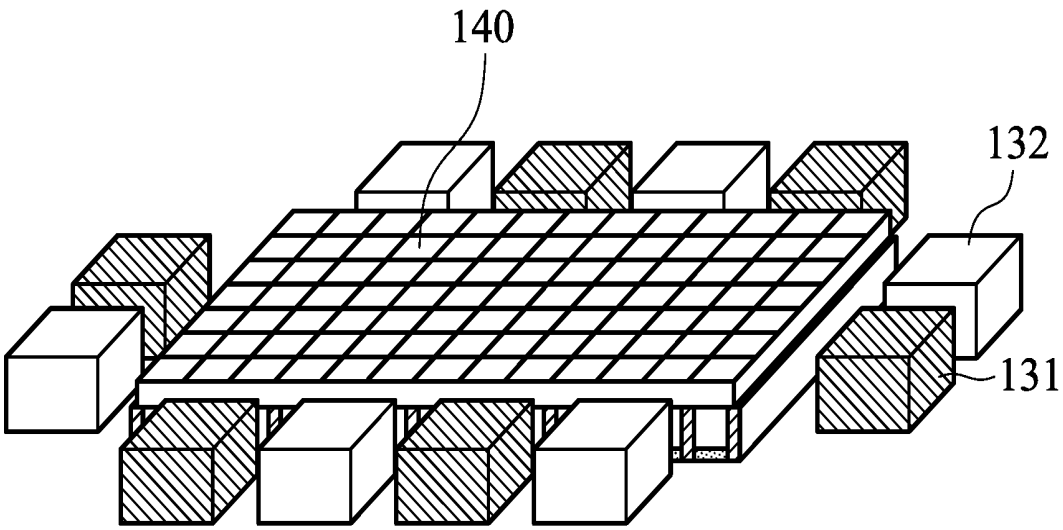


FIG. 2

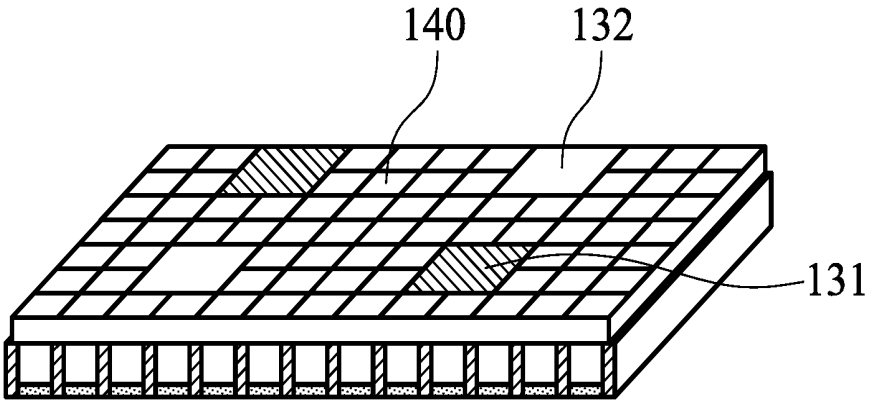


FIG. 3

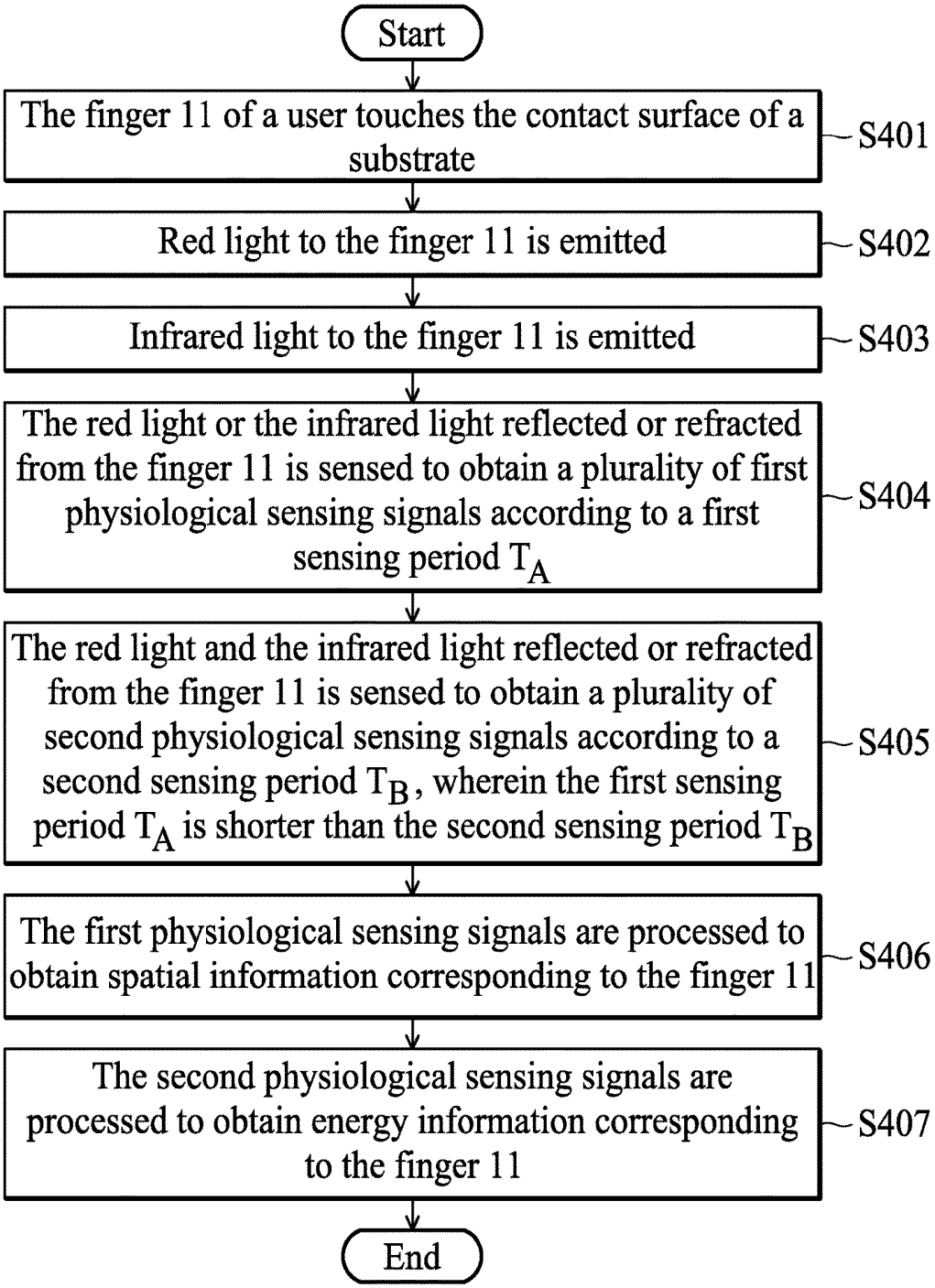

Start
The finger 11 of a user touches the contact surface of a substrate
S401
Red light to the finger 11 is emitted
S402
Infrared light to the finger 11 is emitted
S403
The red light or the infrared light reflected or refracted from the finger 11 is sensed to obtain a plurality of first physiological sensing signals according to a first sensing period T_A
S404
The red light and the infrared light reflected or refracted from the finger 11 is sensed to obtain a plurality of second physiological sensing signals according to a second sensing period T_B, wherein the first sensing period T_A is shorter than the second sensing period T_B
S405
The first physiological sensing signals are processed to obtain spatial information corresponding to the finger 11
S406
The second physiological sensing signals are processed to obtain energy information corresponding to the finger 11
S407
End

FIG. 4

MULTIPLE PHYSIOLOGICAL SIGNALS SENSING CHIP AND THE MULTIPLE PHYSIOLOGICAL SIGNALS SENSING METHOD THEREOF

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application is based on, and claims priority from, TW Application Number 105121064, filed on Jul. 4, 2016, the invention of which is hereby incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The invention relates to a sensing device used to sense multiple physiological signals, and more particularly to sense multiple physiological signals using a single chip.

BACKGROUND

[0003] Currently, fingerprint sensing techniques adopted in commercial electronic devices mostly use capacitive sensing methods, and blood oxygen or heartbeat sensing techniques adopted in commercial electronic devices mostly use optical sensing methods. Due to the rapid development of semiconductor technology, development of related electronic products towards the direction of integrating multiple applications. In view of this, the present invention provides a multiple physiological signals sensing chip and a corresponding multiple physiological signals sensing method.

SUMMARY

[0004] An embodiment of the present invention provides a multiple physiological signals sensing chip. The multiple physiological signals sensing chip comprises a substrate, at least one first light-emitting diode, at least one second light-emitting diode, a sensing array, and a processing unit. The substrate comprises a contact surface touched by a finger of a user. The at least one first light-emitting diode is used to emit red light to the finger. The at least one second light-emitting diode is used to emit infrared light to the finger. The sensing array senses the red light or the infrared light reflected or refracted from the finger to obtain a plurality of first physiological sensing signals according to a first sensing period or senses the red light and the infrared light reflected or refracted from the finger to obtain a plurality of second physiological sensing signals according to a second sensing period, wherein the first sensing period is shorter than the second sensing period. The processing unit is connected to the at least one first light-emitting diode, the at least one second light-emitting diode and the sensing array, wherein the processing unit operates the at least one first light-emitting diode, the at least one second light-emitting diode and the sensing array according to the first sensing period and the second sensing period; and wherein the processing unit processes the first physiological sensing signals to obtain spatial information corresponding to the finger and processes the second physiological sensing signals to obtain energy information corresponding to the finger.

[0005] An embodiment of the present invention provides a multiple physiological signals sensing method. The multiple physiological signals sensing method comprises touching, by a finger of a user, a contact surface of a substrate; emitting red light to the finger; emitting infrared light to the finger; sensing the red light or the infrared light reflected or refracted from the finger to obtain a plurality of first physiological sensing signals according to a first sensing period; sensing the red light and the infrared light reflected or refracted from the finger to obtain a plurality of second physiological sensing signals according to a second sensing period, wherein the first sensing period is shorter than the second sensing period; processing the first physiological sensing signals to obtain spatial information corresponding to the finger; and processing the second physiological sensing signals to obtain energy information corresponding to the finger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The present invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

[0007] FIG. **1**A and FIG. **1**B are block diagrams showing a multiple physiological signals sensing chip **10** according to a first embodiment of the present invention.

[0008] FIG. **2** is a three-dimension (3D) schematic diagram showing a sensing array **140** according to a second embodiment of the present invention.

[0009] FIG. **3** is a 3D schematic diagram showing the sensing array **140** according to a third embodiment of the present invention.

[0010] FIG. **4** shows a flow diagram of a multiple physiological signals sensing method according to a fourth embodiment of the present invention.

DETAILED DESCRIPTION

[0011] The following description is of the best-contemplated mode of carrying out the present invention. This description is made for the purpose of illustrating the general principles of the present invention and should not be taken in a limiting sense. The scope of the present invention is best determined by reference to the appended claims.

[0012] The optical sensing method utilized in the present invention provides a sensing chip integrating multiple physiological signal sensing functions such as a sensing chip integrating a fingerprint sensing function and a heartbeat sensing function.

[0013] FIG. **1**A and FIG. **1**B are block diagrams showing a multiple physiological signals sensing chip **10** for sensing multiple physiological signals according to a first embodiment of the present invention. As shown in FIG. **1**A and FIG. **1**B, in the first embodiment of the present invention, the multiple physiological signals sensing chip **10** comprises a substrate **12**, at least one first light-emitting diode **131**, at least one second light-emitting diode **132**, an image sensor **14**, a processing unit **15** and a diode driving circuit **16**. The substrate **12** comprises a contact surface **121** which can be touched by a finger **11** of a user. The at least one first light-emitting diode **131** is used to emit red light to the finger **11**. The at least one second light-emitting diode **132** is used to emit infrared light to the finger **11**. The image sensor **14** comprises a sensing array **140**, a readout circuit **142** and a body temperature **143**. The readout circuit **142** is respectively connected to the sensing array **140** and the body temperature **143**. The sensing array **140** is composed of a plurality of photosensitive diodes **141** (not shown in FIG. **1**A and FIG. **1**B), and the body temperature **143** is composed of

a third light-emitting diode **133** and a corresponding photosensitive diode **144** (not shown in FIG. **1**A and FIG. **1**B), wherein the third light-emitting diode **133** is used to emit the infrared light having a longer wavelength to the finger **11** and the photosensitive diode **144** is used to sense the infrared light having a longer wavelength reflected or refracted from the finger **11**. The processing unit **15** comprises a fingerprint image processing unit **151** and a blood oxygen signal processing unit **152**, wherein the fingerprint image processing unit **151** and the blood oxygen signal processing unit **152** are respectively connected to the readout circuit **142** of the image sensor **14**. The processing unit **15** is connected to the diode driving circuit **16** and controls the diode driving circuit **16** to drive the first light-emitting diode **131** and the second light-emitting diode **132**.

[0014] In the first embodiment of the present invention, the photosensitive diodes **141** of the sensing array **140** sense the red light or the infrared light reflected or refracted from the finger **11** according to a first sensing period T_A, and the readout circuit **142** of the sensing array **140** reads the corresponding plurality of first physiological sensing signals. The photosensitive diodes **141** of the sensing array **140** also senses the red light or the infrared light reflected or refracted from the finger **11** according to a second sensing period T_B, and the readout circuit **142** of the sensing array **140** reads the corresponding plurality of second physiological sensing signals. It should be noted that, in the first embodiment of the present invention, the first sensing period T_A is shorter than the second sensing period T_B. The processing unit **15** operates the photosensitive diodes **141** and the readout circuit **142** of the sensing array **140** according to the first sensing period T_A and the second sensing period T_B.

[0015] In the first embodiment of the present invention, when the sensing array **140** is operated according to the first sensing period T_A, the first sensing period T_A is short enough that the energy information of reflected light (or refracted light) sensed by the photosensitive diodes **141** is independent of time. Simultaneously, the processing unit **15** also controls luminous time of the first light-emitting diode **131** according to the first sensing period T_A. At this time, the readout circuit **142** of the sensing array **140** reads out the energy information of reflected light (or refracted light) sensed by each of the photosensitive diodes **141**.

[0016] When the finger **11** touches the contact surface **121** of the substrate **12**, fingerprint crests **111** of the finger **11** directly contact the contact surface **121** and fingerprint troughs **112** of the finger **11** do not contact the contact surface **121** due to their containing air. Light from a light source (red light or infrared light) passes through the fingerprint crests **111** to the contact surface **121** of the multiple physiological signals sensing chip **10** so that the photosensitive diodes **141** under the contact surface **121** can sense the light. When light from a light source (red light or infrared light) passes through the fingerprint troughs **112** of the finger **11**, the light is scattered by the air contained by the fingerprint troughs **112** in such a way that the photosensitive diodes **141** under the contact surface **121** cannot sense the light.

[0017] Because the energy information corresponding to the fingerprint crests **111** and the fingerprint troughs **112** of the finger **11** are different, the energy of the reflected light (or the refracted light) sensed by different positions of the photosensitive diodes **141** of the sensing array **140** are different. Therefore the energy information of the reflected light (or the refracted light) sensed by each of the photosensitive diodes **141** has spatial difference.

[0018] Accordingly, in the first embodiment of the present invention, the processing unit **15** adjusts the first sensing period T_A so that the first physiological sensing signals of the photosensitive diodes **141** of the sensing array **140** are a plurality of time invariant signals which have a spatial association between each other. For example, the photosensitive diodes **141** of the sensing array **140** sense instantaneously reflected light (or instantaneous refracted light) from the finger **11**. At this time, the readout circuit **142** of the sensing array **140** reads out the first physiological sensing signals from the photosensitive diodes **141**.

[0019] In the first embodiment of the present invention, the fingerprint image processing unit **151** of the processing unit **15** has a gain amplifier, an analog-to-digital circuit and a digital signal processing circuit. Accordingly, the fingerprint image processing unit **151** can process a plurality of sampling signals (i.e. the first physiological sensing signals) read from the readout circuit **142** to obtain spatial information corresponding to the finger **11**, wherein the spatial information comprises the positions of the fingerprint crests **111** and the positions of the fingerprint troughs **112**. In other words, the spatial information comprises the fingerprint pattern of the finger **11**.

[0020] In the first embodiment of the present invention, the processing unit **15** adjusts the second sensing period T_B so that the second physiological sensing signals sensed by the photosensitive diodes **141** of the sensing array **140** are time varying signals. Simultaneously, the processing unit **15** also controls luminous time of the first light-emitting diode **131** and the second light-emitting diode **132** according to the second sensing period T_B.

[0021] Since the second physiological sensing signals are required to be the time varying signals but not the time invariant signals, the second sensing period T_B needs to be longer than the first sensing period T_A. For example, the photosensitive diodes **141** of the sensing array **140** sense the reflected light (or the refracted light) from the finger **11** within a period of time. At this time, the readout circuit **142** of the sensing array **140** determines, according to the second sensing period T_B, total energy information of the reflected light (or the refracted light) sensed by the photosensitive diodes **141**, wherein the total energy information is a continuous signal which is time varying and uncorrelated to the positions. Therefore the readout circuit **142** of the sensing array **140** can readout the second physiological sensing signals represented by the continuous signal from the photosensitive diodes **141**. For example, the red light and the infrared light respectively correspond to two second physiological sensing signals.

[0022] In the first embodiment of the present invention, the blood oxygen signal processing unit **152** of the processing unit **15** has a gain amplifier, an analog-to-digital circuit and a digital signal processing circuit. Accordingly, the blood oxygen signal processing unit **152** can process the two second physiological sensing signals read from the readout circuit **142** (i.e. the two second physiological sensing signals corresponding to the red light and the infrared light) to obtain energy information from the finger **11**, wherein the energy information comprises blood oxygen information of the finger **11** and heartbeat information of the finger **11**.

[0023] In the first embodiment of the present invention, the blood oxygen signal processing unit **152** further operates

the body temperature sensor **143** of the image sensor **14** according to a third sensing period T_C, wherein the third sensing period T_C is longer than the first sensing period T_A. For example, the body temperature sensor **143** of the image sensor **14** senses the infrared light reflected or refracted from the finger **11** within a period of time, then the readout circuit **142** can read a third physiological sensing signal represented by a continuous signal from the body temperature sensor **143** according to the third sensing period T_C. In the first embodiment of the present invention, the third physiological sensing signal is similar to the second physiological sensing signal, and the third physiological sensing signal is a time varying signal containing the total energy information.

[0024] In the first embodiment of the present invention, the first light-emitting diode **131**, the second light-emitting diode **132**, the image sensor **14**, the processing unit **15** and the diode driving circuit **16** can be integrated into a silicon chip with a planar manner. Accordingly, the multiple physiological signals sensing chip **10** of the present invention can obtain the fingerprint pattern, the blood oxygen information and heartbeat information corresponding to the finger **11** using an optical sensing method performed by the sensing array of only one chip.

[0025] In addition, it should be noted that the multiple physiological signals sensing chip **10** is required to use at least two light sources with different wavelengths (i.e. there is a need to turn on the first light-emitting diode **131** and the light-emitting diode **132**) only when the multiple physiological signals sensing chip **10** needs to obtain the blood oxygen information. In other words, in other embodiments of the present invention, the multiple physiological signals sensing chip **10** can obtain the fingerprint pattern, the body temperature information and the heartbeat information corresponding to the finger **11** with only single-wavelength light source (for example, it only turns on the first light-emitting diode **131** or the light-emitting diode **132**).

[0026] In other embodiments of the present invention, the multiple physiological signals sensing chip **10** is not limited to using the red light source or the infrared light source. For example, the multiple physiological signals sensing chip **10** may also use another light-emitting diode which emits light having another wavelength and thereby obtain physiological information from the finger **11** (for example, fingerprint pattern, blood oxygen information, body temperature information, and heartbeat information).

[0027] Since the body temperature sensor **143** is required to sense infrared light which has a longer wavelength, the third light-emitting diode **133** and the photosensitive diode **144** used in the body temperature sensor **143** are mostly implemented by III-V semiconductors. Then a body temperature sensor **143** implemented by III-V semiconductor is integrated into the multiple physiological signals sensing chip **10** through encapsulation.

[0028] In addition, it should be noted that, if the body temperature sensor **143** is implemented by silicon, the body temperature sensor **143** also can be implemented in the same chip (or implemented in the same sensing array **140**). At this time, the multiple physiological signals sensing chip **10** can obtain the fingerprint pattern, the blood oxygen information, the body temperature information and the heartbeat information corresponding to the finger **11** by an optical sensing method with the sensing array of only one chip.

[0029] In another embodiment of the present invention, the processing unit **15** controls the sensing array **140** operating in the first sensing period T_A, the readout circuit **142** of the sensing array **140** reads all the first physiological sensing signals. At this time, the fingerprint image processing unit **151** processes all the first physiological sensing signals to obtain spatial information of the finger **11** (for example, the fingerprint pattern of the finger **11**), and the blood oxygen signal processing unit **152** of the processing unit **15** processes all the first physiological sensing signals to obtain a first physiological sensing average signal, wherein the first physiological sensing average signal represents an average value sensed by the photosensitive diodes **141** of the sensing array **140** during the first sensing period T_A. Since the first sensing period T_A is very short (for example, 5 milliseconds), the first physiological sensing average signal is also a time invariant signal. In addition, the magnitude of the first physiological sensing average signal is related to the sensing time of the sensing array **140**.

[0030] In the same way, the processing unit **15** controls the sensing array **140** and the diode driving circuit **16** at different sensing times such that the blood oxygen signal processing unit **152** respectively obtains the first physiological sensing average signals. For example, the processing unit **15** controls the sensing array **140** operating in the first sensing period T_A in every 100 milliseconds such that the blood oxygen signal processing unit **152** obtains 1000 first physiological sensing average signals in 100 seconds. At this time, since each of the first physiological sensing average signals at different sensing time is distinct, the 1000 first physiological sensing average signals can be considered as a time varying signal. That is, 1000 discrete values form single time varying signal. Then the blood oxygen signal processing unit **152** can process the time varying signal (1000 first physiological sensing average signals) corresponding to the red light and the time varying signal (1000 first physiological sensing average signals) corresponding to the infrared light to obtain the blood oxygen information and the heartbeat information corresponding to the finger **11**.

[0031] Accordingly, in the above embodiment of the present invention, the image sensor **14** of the multiple physiological signals sensing chip **10** operates with an identical sensing period (for example, it always operates with the first sensing period T_A) to obtain the fingerprint pattern, the blood oxygen information and the heartbeat information corresponding to the finger **11**.

[0032] FIG. **2** is a 3D schematic diagram showing a sensing array **140** according to a second embodiment of the present invention. In the second embodiment of the present invention, in order to let the infrared light/red light more uniformly reflect/refract to the sensing array, six first light-emitting diodes **131** and six second light-emitting diodes **132** are uniformly disposed around the sensing array **140**.

[0033] FIG. **3** is a 3D schematic diagram showing the sensing array **140** according to a third embodiment of the present invention. In the third embodiment of the present invention, in order to reduce the designed area of the multiple physiological signals sensing chip **10**, the first light-emitting diodes **131** and the second light-emitting diodes **132** are integrated into the sensing array **140**. At this time, the sensing array **140** is large enough so that loss of pixels due to the above configuration (integrating it into the sensing array **140**) is not enough to influence fingerprint recognition.

[0034] FIG. **4** shows a flow diagram of a multiple physiological signals sensing method according to a fourth

embodiment of the present invention. In step **S401**, the finger **11** of a user touches the contact surface of a substrate. In step **S402**, red light to the finger **11** is emitted. In step **S403**, infrared light to the finger **11** is emitted. In step **S404**, the red light or the infrared light reflected or refracted from the finger **11** is sensed to obtain a plurality of first physiological sensing signals according to a first sensing period T_A. In step **S405**, the red light and the infrared light reflected or refracted from the finger **11** is sensed to obtain a plurality of second physiological sensing signals according to a second sensing period T_B, wherein the first sensing period T_A is shorter than the second sensing period T_B. In step **S406**, the first physiological sensing signals are processed to obtain spatial information corresponding to the finger **11**. In step **S407**, the second physiological sensing signals are processed to obtain energy information corresponding to the finger **11**.

[0035] The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the present invention. Those skilled in the art should appreciate that they may readily use the present invention as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present invention, and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the present invention.

What is claimed is:

1. A multiple physiological signals sensing chip, comprising:

a substrate, comprising a contact surface touched by a finger of a user;

at least one first light-emitting diode, used to emit red light to the finger;

at least one second light-emitting diode, used to emit infrared light to the finger;

a sensing array, sensing the red light or the infrared light reflected or refracted from the finger to obtain a plurality of first physiological sensing signals according to a first sensing period or sensing the red light and the infrared light reflected or refracted from the finger to obtain a plurality of second physiological sensing signals according to a second sensing period, wherein the first sensing period is shorter than the second sensing period; and

a processing unit, connected to the at least one first light-emitting diode, the at least one second light-emitting diode and the sensing array, wherein the processing unit operates the at least one first light-emitting diode, the at least one second light-emitting diode and the sensing array according to the first sensing period and the second sensing period; and

wherein the processing unit processes the first physiological sensing signals to obtain spatial information corresponding to the finger and processes the second physiological sensing signals to obtain energy information corresponding to the finger.

2. The multiple physiological signals sensing chip of claim **1**, wherein the processing unit adjusts the first sensing period such that the first physiological sensing signals sensed by the sensing array are time invariant signals; and

wherein the processing unit adjusts the second sensing period such that the second physiological sensing signals sensed by the sensing array are time varying signals.

3. The multiple physiological signals sensing chip of claim **2**, wherein the processing unit further processes the first physiological sensing signals to obtain a first physiological sensing average signal;

wherein the processing unit operates the sensing array at different time points to obtain the first physiological sensing average signal corresponding to each time point; and

wherein the processing unit processes the first physiological sensing average signals to obtain blood oxygen information of the finger and heartbeat information of the finger.

4. The multiple physiological signals sensing chip of claim **1**, wherein the spatial information is a fingerprint pattern of the finger; and

wherein the energy information comprises blood oxygen information of the finger and heartbeat information of the finger.

5. The multiple physiological signals sensing chip of claim **1**, further comprising:

a body temperature sensor, connected to the processing unit, wherein the processing unit operates the body temperature sensor according to a third sensing period and the sensing period is longer than the first sensing period; and

wherein the body temperature sensor senses the infrared light reflected from the finger to obtain a plurality of third physiological sensing signals according to the third sensing period such that the processing unit processes the third physiological sensing signals to obtain body temperature information of the finger.

6. The multiple physiological signals sensing chip of claim **1**, wherein the at least one first light-emitting diode and the at least one second light-emitting diode surround the sensing array.

7. The multiple physiological signals sensing chip of claim **1**, wherein the at least one first light-emitting diode and the at least one second light-emitting diode are disposed in the sensing array.

8. A multiple physiological signals sensing method, comprising:

touching, by a finger of a user, a contact surface of a substrate;

emitting red light to the finger;

emitting infrared light to the finger;

sensing the red light or the infrared light reflected or refracted from the finger to obtain a plurality of first physiological sensing signals according to a first sensing period;

sensing the red light and the infrared light reflected or refracted from the finger to obtain a plurality of second physiological sensing signals according to a second sensing period, wherein the first sensing period is shorter than the second sensing period;

processing the first physiological sensing signals to obtain spatial information corresponding to the finger; and

processing the second physiological sensing signals to obtain energy information corresponding to the finger.

9. The multiple physiological signals sensing method of claim **8**, further comprising:

adjusting the first sensing period such that the first physiological sensing signals are time invariant signals; and

adjusting the second sensing period such that the second physiological sensing signals are time varying signals.

10. The multiple physiological signals sensing method of claim **9**, further comprising:

processing the first physiological sensing signals to obtain a first physiological sensing average signal;

sensing at different time points to obtain the first physiological sensing average signal corresponding to each time point; and

processing the first physiological sensing average signals to obtain blood oxygen information of the finger and heartbeat information of the finger.

11. The multiple physiological signals sensing method of claim **8**, wherein the spatial information is a fingerprint pattern of the finger; and

wherein the energy information comprises blood oxygen information of the finger and heartbeat information of the finger.

12. The multiple physiological signals sensing method of claim **8**, further comprising:

sensing the infrared light reflected from the finger to obtain a plurality of third physiological sensing signals according to the third sensing period, wherein the sensing period is longer than the first sensing period; and

processing the third physiological sensing signals to obtain body temperature information of the finger.

* * * * *

专利名称(译)	多个生理信号传感芯片及其多种生理信号传感方法		
公开(公告)号	US20180000393A1	公开(公告)日	2018-01-04
申请号	US15/263189	申请日	2016-09-12
[标]申请(专利权)人(译)	国立清华大学		
申请(专利权)人(译)	清大		
当前申请(专利权)人(译)	清大		
[标]发明人	HSIEH CHIH CHENG CHIOU ALBERT YEN CHIH		
发明人	HSIEH, CHIH-CHENG CHIOU, ALBERT YEN-CHIH		
IPC分类号	A61B5/1455 A61B5/0205 A61B5/00		
CPC分类号	A61B5/14552 A61B2562/0238 A61B5/6826 A61B5/02055 A61B5/1172 A61B2562/046 G06K9/00892 G06K2009/0006		
优先权	105121064 2016-07-04 TW		
外部链接	Espacenet USPTO		

摘要(译)

提供了一种多生理信号传感芯片。多生理信号传感芯片包括基板，第一发光二极管，第二发光二极管，传感阵列和处理单元。基板包括由手指触摸的接触表面。第一和第二发光二极管分别向手指发射红光和红外光。感测阵列感测从手指反射或折射的红光或红外光，以根据第一感测周期获得第一生理感测信号，或感测红光和从手指反射或折射的红外光，以获得第二生理感测信号根据第二感知期。第一感测周期短于第二感测周期。处理单元分别处理第一和第二生理感测信号，以获得与手指对应的空间信息和能量信息。