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(54) **ULTRASOUND PROBE AND ULTRASOUND SYSTEM**

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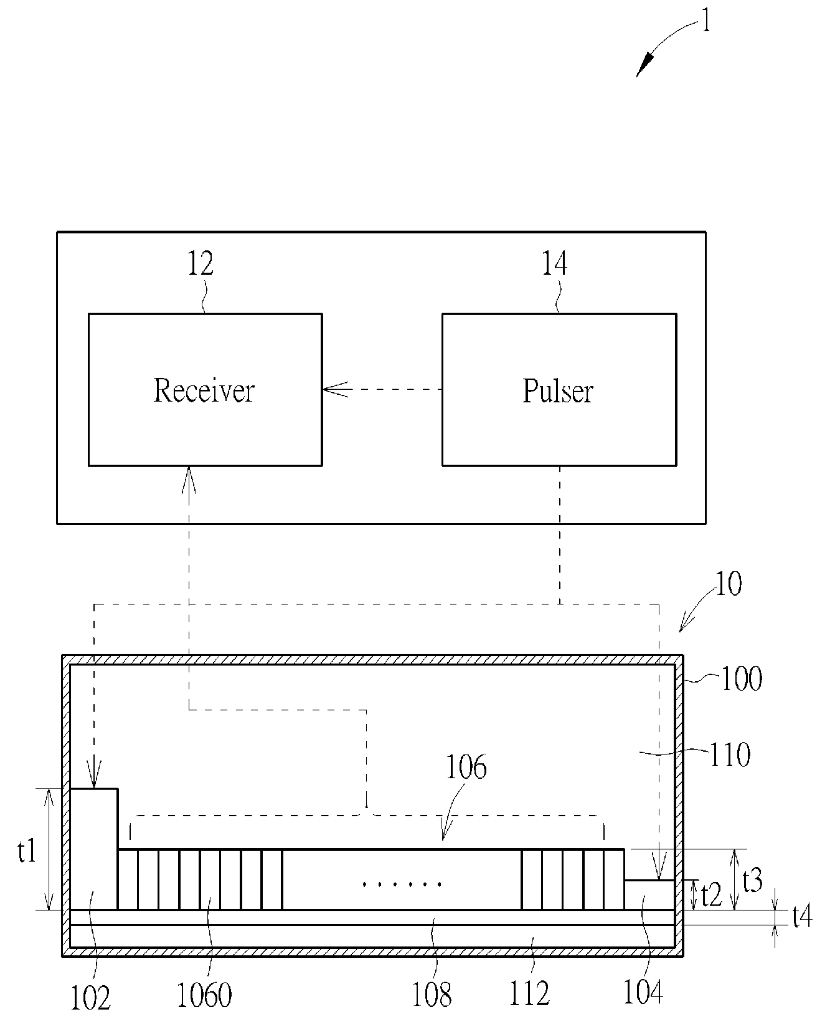
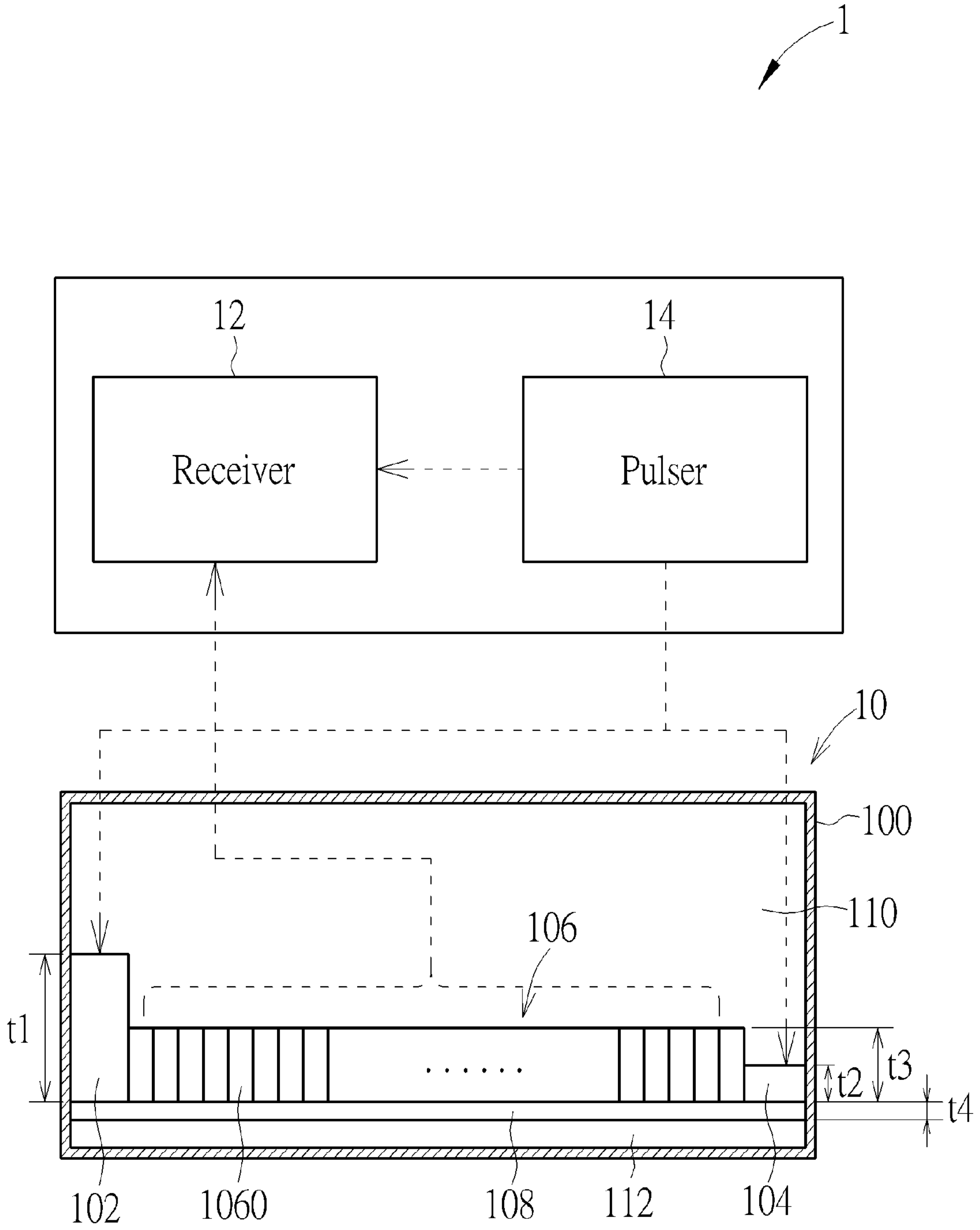
(57) **ABSTRACT**

An ultrasound probe includes a casing, a first transmitting unit, a second transmitting unit and a receiving unit. The first transmitting unit is used for transmitting a first push beam and the first push beam has a first transmitting frequency. The second transmitting unit is used for transmitting a second push beam and the second push beam has a second transmitting frequency. The receiving unit has a receiving frequency and is used for selectively receiving a reflective wave of the first push beam and the second push beam, wherein the receiving frequency is covered with the first transmitting frequency and the second transmitting frequency. The receiving unit, the first transmitting unit and the second transmitting unit are disposed in the casing side by side.




1
12
14
Receiver
Pulser
10
100
110
106
t1
t2
t3
t4
......
102
1060
108
112
104

FIGURE

ULTRASOUND PROBE AND ULTRASOUND SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of China Application No. 201610363265.7, which was filed on May 27, 2016, and is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The invention relates to an ultrasound probe and an ultrasound system and, more particularly, to an ultrasound probe and an ultrasound system capable of transmitting two push beams with different frequencies.

2. Description of the Prior Art

[0003] Since ultrasound scanning equipments do not destroy material structure and cell, ultrasound scanning equipments are in widespread use for the field of material and clinical diagnosis. When an ultrasound probe is scanning, the ultrasound probe transmits a push beam with a specific intensity to a tissue, so as to vibrate the tissue. Then, the vibration spreads in all directions with a specific speed based on a characteristic of the tissue, wherein a reflective wave perpendicular to a direction of the push beam is called "shear wave". Since a wave speed of the shear wave changes with the hardness of the tissue, the hardening of the tissue can be obtained by measuring the wave speed of the shear wave. In general, a shear wave generated by a push beam with low frequency may spread with a long distance, but the resolution is bad. Therefore, the push beam with low frequency is suitable for scanning a tissue of liver, breast or the like. Furthermore, a shear wave generated by a push beam with high frequency may spread with a short distance, but the resolution is good. Therefore, the push beam with high frequency is suitable for scanning a tissue of a small area. In the prior art, the ultrasound probe can only transmit a push beam with one single frequency. When a doctor wants to perform the ultrasound scanning for tissues located at different distances, he/she has to change different ultrasound probes and it is very inconvenient in use.

SUMMARY OF THE INVENTION

[0004] An objective of the invention is to provide an ultrasound probe and an ultrasound system capable of transmitting two push beams with different frequencies, so as to solve the aforesaid problems.

[0005] According to an embodiment of the invention, an ultrasound probe comprises a casing, a first transmitting unit, a second transmitting unit and a receiving unit. The first transmitting unit is used for transmitting a first push beam and the first push beam has a first transmitting frequency. The second transmitting unit is used for transmitting a second push beam and the second push beam has a second transmitting frequency. The receiving unit has a receiving frequency and the receiving unit is used for selectively receiving a reflective wave of the first push beam and the second push beam, wherein the receiving frequency is covered with the first transmitting frequency and the second transmitting frequency. The receiving unit, the first transmitting unit and the second transmitting unit are disposed in the casing side by side.

[0006] According to another embodiment of the invention, an ultrasound system comprises an ultrasound probe, a receiver and a pulser. The ultrasound probe comprises a casing, a first transmitting unit, a second transmitting unit and a receiving unit. The first transmitting unit is used for transmitting a first push beam and the first push beam has a first transmitting frequency. The second transmitting unit is used for transmitting a second push beam and the second push beam has a second transmitting frequency. The receiving unit has a receiving frequency, wherein the receiving frequency is covered with the first transmitting frequency and the second transmitting frequency. The receiving unit, the first transmitting unit and the second transmitting unit are disposed in the casing side by side. The receiver is electrically connected to the receiving unit. The pulser is electrically connected to the first transmitting unit, the second transmitting unit and the receiver. The pulser is used for triggering the first transmitting unit and the second transmitting unit to selectively transmit the first push beam and the second push beam.

[0007] As mentioned in the above, the invention integrates the two transmitting units and the receiving unit into the ultrasound probe, wherein the two transmitting units can transmit two push beams with different frequencies. Accordingly, the ultrasound probe of the invention can selectively transmit a push beam with low frequency to scan a tissue of liver, breast or the like or transmit a push beam with high frequency to scan a tissue of a small area. In other words, the ultrasound probe of the invention can perform ultrasound scanning for tissues located at different distances. Therefore, the invention is very convenient in use.

[0008] These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the FIGURE.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The FIGURE is a schematic diagram illustrating an ultrasound system according to an embodiment of the invention.

DETAILED DESCRIPTION

[0010] Referring to the FIGURE, the FIGURE is a schematic diagram illustrating an ultrasound system **1** according to an embodiment of the invention. As shown in the FIGURE, the ultrasound system **1** comprises an ultrasound probe **10**, a receiver **12** and a pulser **14**. The ultrasound probe **10** comprises a casing **100**, a first transmitting unit **102**, a second transmitting unit **104** and a receiving unit **106**, wherein the receiving unit **106**, the first transmitting unit **102** and the second transmitting unit **104** are disposed in the casing **100** side by side. The receiver **12** is electrically connected to the receiving unit **106** and the pulser **14** is electrically connected to the first transmitting unit **102**, the second transmitting unit **104** and the receiver **12**. Furthermore, the ultrasound probe **10** further comprises a matching layer **108**, a backing layer **110** and a lens **112**, wherein the matching layer **108** is disposed on the receiving unit **106**, the first transmitting unit **102** and the second transmitting unit **104**, the backing layer **110** and the matching layer **108** are disposed at opposite sides of the receiving unit **106**, the first transmitting unit **102** and the second transmitting unit **104**, and the lens **112** is disposed in the matching layer **108**. The receiving unit **106** may also be used as a common diagnostic probe for scanning tissue structure. In this embodiment, the receiving unit **106** is used for receiving a reflective wave when detecting a shear wave. It should be noted that the ultrasound system **1** and the ultrasound probe **10** may be further equipped with other necessary circuits and components according to practical applications and those will not be depicted herein.

[0011] In this embodiment, the first transmitting unit **102** and the second transmitting unit **104** are located at opposite sides of the receiving unit **106**. However, in another embodiment, the first transmitting unit **102** and the second transmitting unit **104** may be located at an identical side of the receiving unit **106** according to practical applications.

[0012] The receiving unit **106**, the first transmitting unit **102** and the second transmitting unit **104** may be made of a piezoelectric material, wherein the piezoelectric material may be lead zirconate titanate (PZT), polyvinylidene (PVDF), Lithium Niobate (LiNbO3), PMNPT or other piezoelectric materials. Furthermore, the receiving unit **106** may essentially consist of a plurality of channels **1060**, wherein the number of the channels **1060** may be 64, 128, 192, 256 or other values according to practical applications. It should be noted that a common coaxial cable has 134 cores. If the number of the channels **1060** of the receiving unit **106** is 128, the signal lines of the receiving unit **106**, the first transmitting unit **102** and the second transmitting unit **104** may be integrated into one single coaxial cable.

[0013] In this embodiment, the first transmitting unit **102** is used for transmitting a first push beam and the second transmitting unit **104** is used for transmitting a second push beam, wherein the first push beam has a first transmitting frequency and the second push beam has a second transmitting frequency. Furthermore, the receiving unit **106** has a receiving frequency, wherein the receiving frequency is covered with the first transmitting frequency and the second transmitting frequency.

[0014] In general, an oscillation frequency of the ultrasound probe is related to a thickness of the piezoelectric material. The thickness of the piezoelectric material is equal to ½ wavelength and the relationship between wavelength, sound speed of material and center frequency is represented by the following equation 1.

wavelength=sound speed of material/center frequency. Equation 1:

center frequency=$(FL+FH/2)$. Equation 2:

Where:

[0015] A Fast Fourier Transform (FFT) is performed on the echo pulse and the −6 dB levels of the rising edge (FL) and falling edge (FH) of the spectrum are summed then divided by two.

Operating Bandwidth=$(FH-FL/$center frequency$)$ *100. Equation 3:

Where:

[0016] A Fast Fourier Transform (FFT) is performed on the echo pulse. The difference from the −20 dB levels of the rising edge (FL) and falling edge (FH) of the spectrum are divided by the center frequency (FC) then multiplied by one hundred. It's usually more than 100% in the ultrasound transducer.

[0017] Accordingly, in the invention, a thickness t**3** of the receiving unit **106** maybe between a thickness t**1** of the first transmitting unit **102** and a thickness t**2** of the second transmitting unit **104**, such that the receiving frequency of the receiving unit **106** may be between the first transmitting frequency of the first transmitting unit **102** and the second transmitting frequency of the second transmitting unit **104**. For example, when the thickness t**3** of the receiving unit **106** is ½ times the thickness t**1** of the first transmitting unit **102** and the thickness t**2** of the second transmitting unit **104** is ¼ times the thickness t**1** of the first transmitting unit **102**, the receiving frequency of the receiving unit **106** is two times the first transmitting frequency of the first transmitting unit **102** and the second transmitting frequency of the second transmitting unit **104** is four times the first transmitting frequency of the first transmitting unit **102**. At this time, the wavelength of the matching layer **108** may be ¼, ⅛ and 1/16. Accordingly, a thickness t**4** of the matching layer **108** of the invention may be uniform, wherein the thickness t**4** of the matching layer **108** is corresponding to the first transmitting frequency, two times the first transmitting frequency (i.e. the receiving frequency), and four times the first transmitting frequency (i.e. the second transmitting frequency), i.e. equal to ¼ wavelength of the first transmitting frequency, ⅛ wavelength of the receiving frequency and 1/16 wavelength of the second transmitting frequency. In practical system design, the first transmitting frequency of the first transmitting unit **102** may be selected within a bandwidth range of 2-5 MHz with a center frequency of 3 MHz, the receiving frequency of the receiving unit **106** may receive a transmitting signal within bandwidth range of 3-9 MHz with a center frequency of 6 MHz, and the second transmitting frequency of the second transmitting unit **104** may be selected within a bandwidth range of 6-18 MHz with a center frequency of 12 MHz. However, the invention is not limited to the aforesaid embodiments.

[0018] It should be noted that if the relationship between the first transmitting frequency of the first transmitting unit **102**, the receiving frequency of the receiving unit **106** and the second transmitting frequency of the second transmitting unit **104** is not a multiple of **2**, the thickness of the matching layer **108** may be various, so as to be corresponding to the first transmitting frequency of the first transmitting unit **102**, the receiving frequency of the receiving unit **106** and the second transmitting frequency of the second transmitting unit **104**.

[0019] When the ultrasound system **1** of the invention is used to perform ultrasound scanning, the pulser **14** is used for triggering the first transmitting unit **102** and the second transmitting unit **104** to selectively transmit the first push beam and the second push beam and the receiving unit **106** is used for selectively receiving a reflective wave (i.e. shear wave) of the first push beam and the second push beam.

[0020] For example, when a doctor wants to use the ultrasound system **1** of the invention to scan a tissue of liver, breast or the like, he/she can operate the pulser **14** to trigger the first transmitting unit **102** to transmit a first push beam with a first frequency (e.g. 3 MHz, low frequency) and then the receiving unit **106** receives a reflective wave of the first push beam. At this time, the pulser **14** will trigger the receiver **12** to receive the reflective wave of the first push beam from the receiving unit **106**. Then, a backend control circuit (not shown) processes the reflective wave of the first push beam and generates an image. Similarly, when the doctor wants to use the ultrasound system **1** of the invention to scan a tissue of a small area, he/she can operate the pulser **14** to trigger the second transmitting unit **104** to transmit a second push beam with a second frequency (e.g. 12 MHz, high frequency) and then the receiving unit **106** receives a reflective wave of the second push beam. At this time, the pulser **14** will trigger the receiver **12** to receive the reflective wave of the second push beam from the receiving unit **106**. Then, the backend control circuit (not shown) processes the reflective wave of the second push beam and generates an image.

[0021] As mentioned in the above, the invention integrates the two transmitting units and the receiving unit into the ultrasound probe, wherein the two transmitting units can transmit two push beams with different frequencies. Accordingly, the ultrasound probe of the invention can selectively transmit a push beam with low frequency to scan a tissue of liver, breast or the like or transmit a push beam with high frequency to scan a tissue of a small area. In other words, the ultrasound probe of the invention can perform ultrasound scanning for tissues located at different distances. Therefore, the invention is very convenient in use.

[0022] Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. An ultrasound probe comprising:
- a casing;
- a first transmitting unit for transmitting a first push beam, the first push beam having a first transmitting frequency;
- a second transmitting unit for transmitting a second push beam, the second push beam having a second transmitting frequency; and
- a receiving unit having a receiving frequency, the receiving unit being used for selectively receiving a reflective wave of the first push beam and the second push beam, the receiving frequency being covered with the first transmitting frequency and the second transmitting frequency, the receiving unit, the first transmitting unit and the second transmitting unit being disposed in the casing side by side.

2. The ultrasound probe of claim **1**, wherein the first transmitting unit and the second transmitting unit are located at opposite sides of the receiving unit.

3. The ultrasound probe of claim **1**, wherein a thickness of the receiving unit is between a thickness of the first transmitting unit and a thickness of the second transmitting unit.

4. The ultrasound probe of claim **1**, wherein the receiving frequency is two times the first transmitting frequency and the second transmitting frequency is four times the first transmitting frequency.

5. The ultrasound probe of claim **1**, wherein the receiving unit, the first transmitting unit and the second transmitting unit are made of a piezoelectric material.

6. The ultrasound probe of claim **1**, wherein the receiving unit essentially consists of a plurality of channels.

7. The ultrasound probe of claim **1**, further comprising a matching layer disposed on the receiving unit, the first transmitting unit and the second transmitting unit, a thickness of the matching layer being uniform. **8** . The ultrasound probe of claim **7**, further comprising a backing layer, the backing layer and the matching layer being disposed at opposite sides of the receiving unit, the first transmitting unit and the second transmitting unit.

9. The ultrasound probe of claim **7**, further comprising a lens disposed on the matching layer.

10. The ultrasound probe of claim **1**, wherein a thickness of the receiving unit is ½ times a thickness of the first transmitting unit and a thickness of the second transmitting unit is ¼ times the thickness of the first transmitting unit.

11. An ultrasound system comprising:
- an ultrasound probe comprising:
  - a casing;
  - a first transmitting unit for transmitting a first push beam, the first push beam having a first transmitting frequency;
  - a second transmitting unit for transmitting a second push beam, the second push beam having a second transmitting frequency; and
  - a receiving unit having a receiving frequency, the receiving frequency being covered with the first transmitting frequency and the second transmitting frequency, the receiving unit, the first transmitting unit and the second transmitting unit being disposed in the casing side by side;
- a receiver electrically connected to the receiving unit; and
- a pulser electrically connected to the first transmitting unit, the second transmitting unit and the receiver, the pulser being used for triggering the first transmitting unit and the second transmitting unit to selectively transmit the first push beam and the second push beam.

12. The ultrasound system of claim **11**, wherein the first transmitting unit and the second transmitting unit are located at opposite sides of the receiving unit.

13. The ultrasound system of claim **11**, wherein a thickness of the receiving unit is between a thickness of the first transmitting unit and a thickness of the second transmitting unit.

14. The ultrasound system of claim **11**, wherein the receiving frequency is two times the first transmitting frequency and the second transmitting frequency is four times the first transmitting frequency.

15. The ultrasound system of claim **11**, wherein the receiving unit, the first transmitting unit and the second transmitting unit are made of a piezoelectric material.

16. The ultrasound system of claim **11**, wherein the receiving unit essentially consists of a plurality of channels.

17. The ultrasound system of claim **11**, wherein the ultrasound probe further comprises a matching layer disposed on the receiving unit, the first transmitting unit and the second transmitting unit, and a thickness of the matching layer is uniform.

18. The ultrasound system of claim **17**, wherein the ultrasound probe further comprises a backing layer, and the backing layer and the matching layer are disposed at opposite sides of the receiving unit, the first transmitting unit and the second transmitting unit.

19. The ultrasound system of claim **17**, wherein the ultrasound probe further comprises a lens disposed on the matching layer.

20. The ultrasound system of claim **11**, wherein a thickness of the receiving unit is ½ times a thickness of the first transmitting unit and a thickness of the second transmitting unit is ¼ times the thickness of the first transmitting unit.

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摘要(译)

超声探头包括壳体，第一发送单元，第二发送单元和接收单元。第一发送单元用于发送第一推送波束，第一推送波束具有第一发送频率。第二发送单元用于发送第二推送波束，第二推送波束具有第二发送频率。接收单元具有接收频率，用于选择性地接收第一推波束和第二推波束的反射波，其中接收频率被第一发射频率和第二发射频率覆盖。接收单元，第一发送单元和第二发送单元并排设置在壳体中。