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(54) **SOLID-STATE LASER APPARATUS AND PHOTOACOUSTIC MEASUREMENT APPARATUS**
FESTKÖRPERLASERVORRICHTUNG UND FOTOAKUSTISCHE MESSVORRICHTUNG
APPAREIL LASER À SEMI-CONDUCTEURS ET APPAREIL DE MESURE PHOTOACOUSTIQUE

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a solid-state laser device, and in particular, to a solid-state laser device having a laser chamber storing a laser rod and an excitation lamp.

[0002] The present invention also relates to a photoacoustic measurement device including the solid-state laser device.

2. Description of the Related Art

[0003] Hitherto, as one kind of image inspection method which can noninvasively inspect a state inside a living body, an ultrasonography method has been known. In ultrasonography, an ultrasound probe which can transmit and receive an ultrasonic wave is used. If an ultrasonic wave is transmitted from the ultrasound probe to a subject (living body), the ultrasonic wave advances through the inside of the living body, and is reflected from a tissue interface. The reflected ultrasonic wave is received by the ultrasound probe, and a distance is calculated based on the time until the reflected ultrasonic wave returns to the ultrasound probe, whereby it is possible to image the status of the inside.

[0004] Furthermore, photoacoustic imaging which images the inside of a living body using a photoacoustic effect is known. In general, in photoacoustic imaging, the inside of the living body is irradiated with pulse laser light. Inside the living body, a living body tissue absorbs energy of pulse laser light, and an ultrasonic wave (photoacoustic wave) is generated due to adiabatic expansion caused by energy. The photoacoustic wave is detected by an ultrasound probe or the like, and a photoacoustic image is constituted based on a detection signal, whereby it is possible to visualize the inside of the living body based on the photoacoustic wave.

[0005] In a measurement of a photoacoustic wave, in many cases, it is necessary to emit pulse laser light with high intensity, and a flash lamp excited solid-state laser device is widely used for a light source. The solid-state laser device has a laser rod (laser medium), and a flash lamp (excitation lamp) which excites the laser rod. The laser rod and the excitation lamp are stored inside a laser chamber. The inside of the laser chamber is provided with a reflection surface which allows efficient irradiation of the laser rod with light emitted from the flash lamp or a diffuser which diffuses light and uniformly transmits light to the laser rod.

[0006] In the solid-state laser device, if dust or dirt sticks to an end surface of the laser rod or a reflection surface of a resonator mirror, the energy of laser light is concentrated on this portion, the rod end surface or the mirror reflection surface may be damaged. In order to protect the laser rod or the resonator mirror from dust or dirt, a structure in which a laser rod or a resonator mirror is stored in a boxlike base and the top of the base is covered with a lid to seal the inside of the base airtight is considered (for example, see JP1994-260701A (JP-H06-260701A)).

SUMMARY OF THE INVENTION

[0007] The flash lamp is a consumable, and needs to be replaced regularly. In order to facilitate the replacement of the flash lamp, it is considered that a flash lamp portion of the laser chamber is exposed from a lid portion, and the flash lamp is pulled out from the laser chamber without opening the lid portion. In this case, it is preferable that the end portion of the laser chamber is sealed with the lid portion such that the sealed state of the inside is maintained even at the time of replacement.

[0008] In a case where the flash lamp portion of the laser chamber is exposed from the lid portion, if the end portion of the laser chamber is sealed with the lid portion, the extension direction of the flash lamp and the extension direction of the laser rod are divided by the lid portion. In order to avoid interference of the lid portion with the flash lamp or interference of the lid portion with the laser rod or light emitted from the laser rod, it is necessary to provide that there is a distance between the flash lamp and the laser rod.

[0009] In general, when there is a short distance between the flash lamp and the laser rod, the excitation efficiency is increased. In order to avoid interference of the lid portion, if the distance between the flash lamp and the laser rod is increased, the excitation efficiency is decreased by an increase in distance. In particular, in many cases, a hole portion, into which the flash lamp of the laser chamber is inserted, has an O ring attachment portion for end portion sealing, and the O ring attachment portion has a size greater than the diameter of the hole portion into which the flash lamp is inserted. In order to avoid interference of the O ring attachment portion with the lid portion, it is not possible to narrow the distance between the flash lamp and the laser rod, making it difficult to improve the excitation efficiency.

[0010] In consideration of the above, an object of the invention is to provide a solid-state laser device capable of narrowing the distance between a laser rod center and a flash lamp center while facilitating replacement of an excitation lamp.

[0011] Another object of the invention is to provide a photoacoustic measurement device including the solid-state laser device described above.

[0012] In order to attain the above-described object, the invention provides a solid-state laser device as defined in claim 1, comprising a laser rod, an excitation lamp which emits excitation light to the laser rod, a laser chamber which includes a frame body having an internal space storing the laser rod and the excitation lamp and transmits light emitted from the excitation lamp to the laser rod inside the frame body, a first portion of the frame body storing the excitation lamp having a first hole portion having a diameter greater than the outer diameter of the excitation lamp and a second portion of the frame body storing the laser rod having a second hole portion into which the laser rod is inserted, a pair of mirrors provided on the optical path of a light beam emitted from the laser rod, a housing to which the laser chamber and the pair of mirrors are attached, and a shielding portion which shields the second portion of the frame body of the laser chamber attached to the housing, the pair of mirrors, and the optical path of the light beam emitted from the laser rod from the outside. The first portion of the frame body of the laser chamber further has an O ring attachment portion in which an O ring having an outer diameter greater than the diameter of the first hole portion is attached to an end portion in a longitudinal direction, the excitation lamp is able to be removed from and inserted into the laser chamber intermediated by the first hole portion, and the thickness of at least a part of a region of the shielding portion covering the optical path of the light beam emitted from the second hole portion is smaller than the thickness of other portions of the shielding portion on the outside in the longitudinal direction from the first portion of the frame body of the laser chamber.

[0013] In the solid-state laser device of the invention, the shielding portion may include a plate-shaped lid portion which has an opening which is wider than the laser chamber and an insulating member which closes the opening of the plate-shaped lid portion and has a duct, through which the light beam emitted from the laser rod passes, and the laser chamber may be attached to the housing intermediated by the insulating member.

[0014] The first portion of the frame body of the laser chamber may be exposed from the insulating member.

[0015] The duct may be a through hole formed in the insulating member, and the thickness of a partition wall of the insulating member which separates the outside on the first portion side of the frame body from the through hole may be smaller than the thickness of the plate-shaped lid portion.

[0016] The duct may have a cylindrical shape, the diameter of the cylindrical duct may be greater than the diameter of the light beam emitted from the laser rod, and the central axis of the light beam passing through the cylindrical duct may be deviated in the direction of the first portion of the frame body of the laser chamber from the central axis of the cylindrical duct.

[0017] The duct may be a groove which is formed in the insulating member and has an opening in the direction of the first portion of the frame body of the laser chamber. In this case, the shielding portion may further have a film which covers the opening of the duct, and the thickness of the film may be smaller than the thickness of the plate-shaped lid portion.

[0018] The shielding portion may be constituted of a plate-shaped lid portion, and of the plate-shaped lid portion, the thickness of at least a part of a region covering the optical path of the light beam emitted from the second hole portion may be smaller than the thickness of other portions of the plate-shaped lid portion on the outside in the longitudinal direction from the first portion of the frame body of the laser chamber.

[0019] The frame body may be formed of a metal material.

[0020] The solid-state laser device of the invention may further include an insulating block which is detachably attached to the first portion of the frame body of the laser chamber intermediated by an O ring.

[0021] The length in the longitudinal direction of the first portion of the frame body may be longer than the length in the longitudinal direction of the second portion of the frame body.

[0022] The laser chamber may further have, in the space, a glass material which has a first storage hole having an inner diameter greater than the outer diameter of the excitation lamp and storing the excitation lamp, and a second storage hole having an inner diameter greater than the outer diameter of the laser rod and storing the laser rod therein.

[0023] The invention also provides a photoacoustic measurement device comprising the solid-state laser device of the invention, photoacoustic wave detection means for detecting a photoacoustic wave generated in a subject after the subject has been irradiated with laser light emitted from the solid-state laser device, and signal processing means for carrying out signal processing based on the detected photoacoustic wave.

[0024] According to the solid-state laser device and the photoacoustic measurement device of the invention, it is possible to narrow the distance between a laser rod center and a flash lamp center to increase excitation efficiency while facilitating replacement of an excitation lamp.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

Fig. 1 is a block diagram showing a solid-state laser device according to a first embodiment of the invention.

Fig. 2 is a perspective view showing the appearance of a laser chamber.

Fig. 3 is a sectional view showing a section of a central portion of the laser chamber.

Fig. 4 is a sectional view showing a section of the vicinity of the center of the solid-state laser device.

Fig. 5 is a top view of the solid-state laser device.

Fig. 6 is a sectional view showing the vicinity of an insulating block of Fig. 4 on an enlarged scale.

Fig. 7 is a perspective view showing a solid-state laser device according to a second embodiment of the invention.

Fig. 8 is a perspective view showing the solid-state laser device in a state where a shielding lid is detached from Fig. 7.

Fig. 9 is a sectional perspective view showing a section of the vicinity of an end portion of a first portion of a frame body of a laser chamber on an enlarged scale.

Fig. 10 is a sectional perspective view showing a state where a shielding lid is removed from Fig. 9.

Fig. 11 is a sectional view showing a section of the vicinity of the first portion of the frame body.

Fig. 12 is a sectional view showing a section of the vicinity of the first portion of the frame body in a first modification example.

Fig. 13 is a sectional view showing a section of the vicinity of the first portion of the frame body in a second modification example.

Fig. 14 is a block diagram showing a photoacoustic measurement device including the solid-state laser device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] Hereinafter, an embodiment of the invention will be described in detail referring to the drawings. Fig. 1 shows a solid-state laser device according to a first embodiment of the invention. A solid-state laser device 100 has a laser rod 111, a flash lamp 112, a laser chamber 113, mirrors 114 and 115, a Q switch 116, and a prism 117. The laser rod 111, the flash lamp 112, the laser chamber 113, the mirrors 114 and 115, the Q switch 116, and the prism 117 are disposed in a boxlike housing 118. Though not shown in Fig. 1, the solid-state laser device 100 has a plate-shaped shielding lid which shields the internal space of the housing 118 from the outside. Fig. 1 is a diagram illustrating the components of the solid-state laser device 100, and the spatial positional relationship among the components in Fig. 1 is not necessarily accurately drawn.

[0027] The laser rod 111 is a laser medium. For the laser rod 111, for example, alexandrite crystal formed in a rod shape is used. A laser medium which is used for the laser rod 111 is not particularly limited, and YAG crystal, such as neodymium YAG (yttrium-aluminum-garnet (Nd:YAG)), may be used.

[0028] The flash lamp 112 is an excitation lamp, and emits excitation light to excite the laser rod 111. The laser rod 111 and the flash lamp 112 are stored in the laser chamber 113. The laser chamber 113 has a space for storing the laser rod 111 and the flash lamp 112 therein, and transmits light emitted from the excitation lamp to the laser rod 111 therein. For example, a reflection surface is formed on the inside of the laser chamber 113, and the laser rod 111 is irradiated directly with light emitted from the flash lamp 112, or the laser rod 111 is irradiated with light emitted from the flash lamp 112 and reflected by the reflection surface.

[0029] The laser chamber 113 is connected to cooling equipment 230 through pipings 231 and 232. The cooling equipment 230 is equipment for cooling the laser rod 111 and the flash lamp 112. For example, the cooling equipment 230 feeds a cooling medium, such as pure water, into the laser chamber 113 through the piping 231. The cooling equipment 230 receives water from the laser chamber 113 through the piping 232, decreases the temperature of the cooling medium, and then, feeds the cooling medium into the laser chamber 113 again. In this way, the cooling medium is circulated, whereby it is possible to maintain the temperature of the laser rod 111 in the laser chamber 113 in a desired temperature range.

[0030] The mirrors 114 and 115 are opposed to each other with the laser rod 111 sandwiched therebetween, and a resonator is constituted of the mirrors 114 and 115. For example, the mirror 114 is attached to the side surface of the housing 118 in a transverse direction, and the mirror 115 is attached to the side surface of the housing 118 in a longitudinal direction orthogonal to the side surface in the transverse direction. A prism 117 is disposed between the laser rod 111 and the mirror 115, and light emitted from the laser rod 111 is turned by the prism 117 and is directed toward the mirror 115. The prism 117 may not be provided, and the optical path in the optical resonator may be made linear. The mirror 114 is an output coupler (OC), and the mirror 115 is a total reflection mirror. Laser light as output light is emitted from the mirror 114.

[0031] The Q switch 116 is inserted into the resonator. In Fig. 1, the Q switch 116 is disposed on the optical axis of light induced and emitted from the laser rod 111 between the laser rod 111 and the mirror 114. For the Q switch 116, for example, a Pockels cell which changes the polarization state of light transmitted therethrough according to an applied voltage is used. The Q switch 116 changes the Q value of the resonator according to the applied voltage. After the excitation of the laser rod 111, the Q switch 116 is controlled to rapidly switch the Q value of the resonator from a low Q state to a high Q state, whereby it is possible to make a laser perform Q switch pulse oscillation. In addition to the Pockels cell, a quarter wave plate or a polarizer may be disposed on the optical path of the resonator.

[0032] Fig. 2 is a perspective view showing the appearance of the laser chamber 113. In Fig. 2, holes and the like for connecting the pipings 231 and 232 (see Fig. 1) are not shown. The laser chamber 113 has a frame body 151. The frame body 151 is formed of, for example, a metal material. The frame body 151 has an internal space storing the laser rod 111 and the flash lamp 112. The laser chamber 113 has a diffuser which diffuses light emitted from the flash lamp 112 and transmits light to the laser rod 111 inside the frame body 151. Alternatively, the laser chamber 113 may have a reflection surface instead of the diffuser, and may have such a structure as to reflect light of the flash lamp and to transmit light to the laser rod.

[0033] The frame body 151 has a first portion 151a which stores the flash lamp 112, and a second portion

151b which stores the laser rod 111. The first portion 151a of the frame body has a first hole portion 132 having a diameter greater than the outer diameter of the flash lamp 112. The first portion 151a of the frame body has an O ring attachment portion 133, to which an O ring is attached, in the end portion in the longitudinal direction. The outer diameter of the O ring and the outer diameter of the O ring attachment portion 133 are greater than the diameter of the first hole portion 132. For example, when the diameter of the flash lamp 112 is 5 mm, the diameter of the first hole portion 132 is 6 mm, and the outer diameters of the O ring and the O ring attachment portion 133 are 7 mm. The second portion 151b of the frame body has a second hole portion 131 into which the laser rod 111 is inserted.

[0034] The flash lamp 112 can be removed from and inserted into the laser chamber 113 in the longitudinal direction through the first hole portion 132. The length of the first portion 151a of the frame body in the longitudinal direction is longer than the length of the second portion 151b of the frame body in the longitudinal direction. The lengths of the first portion 151a and the second portion 151b of the frame body in the longitudinal direction may be equal.

[0035] Fig. 3 shows a section of a central portion of the laser chamber 113. The laser chamber 113 has a diffusion material 155 and a glass material 156 in the internal space of the frame body 151. The diffusion material 155 surrounds the laser rod 111 and the flash lamp 112 through the glass material 156. The diffusion material 155 diffuses and reflects incident light. The diffusion material 155 constitutes a reflection surface which reflects light emitted from the flash lamp 112. For the diffusion material 155, for example, barium sulfate, magnesium oxide, or the like is available. Alternatively, alumina ceramics, Spectralon (the product name of Labsphere Inc. in U.S.), or the like may be used.

[0036] The glass material 156 has a first storage hole 157 which stores the flash lamp 112 therein, and a second storage hole 158 which stores the laser rod 111 therein. The inner diameter of the first storage hole 157 is greater than the outer diameter of the flash lamp 112. The inner diameter of the second storage hole 158 is greater than the outer diameter of the laser rod 111. A space between the first storage hole 157 an the flash lamp 112 is filled with a cooling medium, and a space between the second storage hole 158 and the laser rod 111 is filled with a cooling medium. The diameter of the flash lamp 112 is, for example, about 5 mm. The distance between the center of the laser rod 111 and the center of the flash lamp 112 is, for example, about 6 mm to 7 mm.

[0037] Fig. 4 shows a section of the vicinity of the center of the solid-state laser device. The mirror 114, the Q switch 116, the prism 117, and the like are attached to the housing 118. The frame body 151 of the laser chamber is attached to the housing 118 through an insulating member 123. A shielding lid (shielding portion) 119 covers the housing 118, and shields the optical path of a light beam emitted from the mirror 114, the Q switch 116, the prism 117, or the laser rod 111 from the outside. The shielding lid 119 is, for example, insulating resin, such as polycarbonate, nylon, or ABS resin.

[0038] Of the frame body 151 of the laser chamber, the first portion 151a is exposed from the shielding lid 119. To the first portion 151a of the frame body exposed to the outside, an insulating block 121 for insulating the electrodes of the flash lamp 112 (see Fig. 1) is attached through an O ring. The shielding lid 119 has a thin film portion 120 having a thickness smaller than the thickness of other portions of shielding lid 119 in at least a part of a region covering the optical path of laser light on the outside in the longitudinal direction from the first portion 151a of the frame body.

[0039] Fig. 5 is a top view of the solid-state laser device. The mirrors 114 and 115, the Q switch 116, and the prism 117 are sealed in the housing 118 by the shielding lid 119. The first portion 151a of the frame body of the laser chamber is exposed from the shielding lid 119, and the insulating block 121 is on the top of the shielding lid 119. The insulating block 121 is formed of, for example, resin, such as ABS resin or polyacetal resin (POM). The insulating block 121 is screwed to the frame body 151 through the O ring in a state where the solid-state laser device is used. The insulating block 121 is detached from the frame body 151 when replacing the flash lamp 112. The shielding lid 119 has the thin film portion 120 in a predetermined range centering on the optical axis of laser light from the end portion of the first portion 151 a of the frame body in the longitudinal direction of the frame body 151.

[0040] Fig. 6 shows the vicinity of the insulating block 121 on an enlarged scale. The shielding lid 119 extends to the boundary between the frame body 151 and the insulating block 121 so as to maintain sealing of the inside even when the insulating block 121 is detached from the frame body 151. The insulating block 121 is attached to the frame body 151 on the shielding lid 119. Of the shielding lid 119, a portion positioned below the insulating block 121 is the thin film portion 120.

[0041] The thickness of the thin film portion 120 of the shielding lid 119 is referred to as d1, and the thickness of other portions is referred to as d2. For example, the thickness d1 of the thin film portion 120 of the shielding lid 119 is 0.5 mm, and the thickness d2 of other portions is 6 mm. If the thickness of a portion of the shielding lid 119 in contact with the end portion of the first portion 151a of the frame body is not the thickness (d1) of the thin film portion 120 but is the normal thickness (d2), it is necessary to move the positions of the insulating block 121 and the first hole portion 132 and the O ring attachment portion 133 (see Fig. 2) in the first portion 151a of the frame body by the difference in thickness from the thin film portion 120 in a direction away from the second hole portion 131. If the insulating block 121 and the first hole portion 132 of the frame body 151 remain as they are, the thickness of the thin film portion 120 becomes the normal thickness d2, the shielding lid 119 may interfere with laser light.

[0042] In a case where the first portion 151a of the frame body is exposed from the shielding lid 119, in particular, the O ring attachment portion 133 in the end portion is likely to interfere with the shielding lid 119. In this embodiment, of the shielding lid 119, a predetermined range from the end portion of the first portion 151a of the frame body having the O ring attachment portion 133 is the thin film portion 120. With this, it is possible to reduce the distance between the laser rod 111 and flash lamp 112 while allowing replacement of the flash lamp 112 without exposing an optical member inside the resonator, compared to a case where the shielding lid 119 is formed to have a uniform thickness, and to improve excitation efficiency.

[0043] If the thickness of the entire shielding lid 119 is made small, it is possible to narrow the distance between the laser rod 111 and the flash lamp 112. However, if the entire shielding lid 119 is formed to have the same thickness as the thin film portion 120, the strength of the shielding lid 119 is insufficient. In this embodiment, in particular, of the shielding lid 119, the thickness of a part of a region extending from the first portion 151a of the frame body and covering the optical path of laser light is made small; thus, it is possible to narrow the distance between the laser rod 111 and the flash lamp 112 while maintaining the overall strength.

[0044] Next, a second embodiment of the invention will be described. Fig. 7 is a perspective view showing a solid-state laser device according to the second embodiment of the invention. Fig. 8 shows the solid-state laser device in a state where a shielding lid 119a is detached from Fig. 7. Mirrors 114 and 115, a Q switch 116, and a prism 117 are sealed in a housing 118 by a plate-shaped shielding lid 119a. The shielding lid 119a is, formed of, metal, such as aluminum or stainless steel.

[0045] At the time of light emission of the flash lamp 112, since a high voltage of several kV is applied to the laser chamber 113, in a case where a metal plate is used for the shielding lid, it is necessary to isolate the shielding lid 119a from the laser chamber 113 in order to prevent the high voltage from being applied to the shielding lid 119a. In this embodiment, the shielding lid 119a has an opening wider than a region corresponding to the laser chamber 113 (the first portion 151a of the frame body). The opening of the shielding lid 119a is closed with the laser chamber 113 and the insulating member 123. The first portion 151a of the frame body of the laser chamber 113 is exposed from the insulating member 123.

[0046] Fig. 9 is a sectional perspective view showing a section of the vicinity of the end portion of the first portion 151a of the frame body of the laser chamber on an enlarged scale. Fig. 10 shows a state where the shielding lid 119a is removed from Fig. 9. The frame body 151 has an O ring attachment portion 133 in the end portion in the longitudinal direction (also see Fig. 2). An O ring 134 is held to be sandwiched between the O ring attachment portion 133 and the insulating block 121. The O ring 134 seals the gap between the first storage hole 157 (see Fig. 3) of the frame body 151 and the flash lamp 112, and prevents overflow of a cooling medium for cooling the flash lamp 112 from the frame body 151 to the outside.

[0047] In a case where the mirror 115 is disposed in a traveling direction of light emitted from the laser rod 111, since the mirror 115 has a size greater than the prism 117, it is necessary to increase the height of the shielding lid 119a by that amount. If the height of the shielding lid 119a in a direction of removing the flash lamp 112 is increased, the flash lamp 112 hits the elevated portion of the shielding lid 119a at the time of removing the flash lamp 112, making it difficult to remove the flash lamp 112. In this embodiment, light is bent at 90° using the prism 117 having a size greater than the mirror 115, and the mirror 115 is disposed on the side surface in the longitudinal direction of the housing, making it easy to remove the flash lamp 112.

[0048] The insulating member 123 has a groove 141 having an opening on the first portion 151a side of the frame body of the laser chamber. The groove 141 is formed in, for example, a rectangular shape. The groove 141 constitutes a duct through which a light beam emitted from the laser rod 111 passes. As shown in Fig. 10, an opening portion of the groove (duct) 141 is covered with a thin film 124 (also see Fig. 8). The thin film 124 is, for example, a polyimide film, and the thickness thereof is smaller than the thickness of the plate-shaped shielding lid 119a. For example, the thickness (corresponding to d2 of Fig. 6) of the shielding lid 119a is 6 mm, and the thickness of the thin film 124 is 100 μm. The insulating block 121 is attached to the end portion of the first portion 151a of the frame body of the laser chamber on the thin film 124. In this embodiment, the insulating member 123 and the thin film 124 constitute a part of a shielding portion.

[0049] Fig. 11 shows a section of the vicinity of the first portion 151a of the frame body. The inside of the housing 118 is closed with the shielding lid 119a and the insulating member 123. The frame body 151 of the laser chamber is attached to the housing 118 through the insulating member 123. The first portion 151a of the frame body is exposed from the insulating member 123, and the second portion 151b is buried in the insulating member 123. The first portion 151a of the frame body has the O ring attachment portion 133 in the attachment portion of the insulating block 121. Laser light emitted from the laser rod 111 passes through the duct 141. The top of the duct 141 is covered with the thin film 124, and the optical path of laser light is protected by the insulating member 123 and the thin film 124 from the outside.

[0050] For example, it is assumed that the diameter of the laser rod 111 is 3 mm, the diameter of the flash lamp 112 is 5 mm, and the distance between the axes of both of the laser rod 111 and the flash lamp 112 is 7 mm. In this case, the shortest distance between the laser rod 111 and the flash lamp 112 becomes 3 mm. If the wire diameter of the O ring for end surface sealing is 1 mm, the shortest distance between the O ring attachment portion 133 and the laser rod 111 becomes about 1.25 mm. Since this distance is short, if a geometric tolerance and a range of fine adjustment of an optical axis are considered, it is difficult to produce a duct (through hole) passing through the insulating member 123 only with machining. Since a high voltage is applied at the time of turning on the flash lamp 112, it is preferable that the laser chamber 113 is attached to the housing intermediated by the insulating member 123; however, the insulating member 123 has poor machining accuracy compared to a metal member. Accordingly, in this embodiment, a groove with an opened top is formed in the insulating member 123, and the top of the groove is covered with the thin film 124.

[0051] In this embodiment, the optical path (duct 141) of laser light is covered with the thin film 124, and the thickness of a partition wall which separates the duct 141 from the outside is smaller than the thickness of the shielding lid 119a. The thickness of this portion is made small, whereby, in particular, it is possible to avoid interference between the O ring attachment portion 133 and the partition wall which separates the duct 141 from the outside. Accordingly, it is possible to reduce the distance between the laser rod 111 and flash lamp 112 while allowing replacement of the flash lamp 112 without exposing an optical member inside the resonator, compared to a case where the shielding lid 119a is formed to have a uniform thickness, and to improve excitation efficiency.

[0052] In the above description, although an example where the thin film 124 is used as the partition wall which separates the duct 141 from the outside has been described, the invention is not limited thereto. Fig. 12 shows a section of the vicinity of the first portion 151a of the frame body of the solid-state laser device in a first modification example. In this example, a through hole 142 formed in the insulating member 123 constitutes a duct. The through hole (duct) 142 is formed in, for example, a cylindrical shape. The thickness of the partition wall (the wall portion of the duct 142) of the insulating member 123 which separates the outside on the first portion 151a side of the frame body and the duct 142 is smaller than the thickness of the shielding lid 119a. If machining accuracy is increased, even though such a duct 142 is formed, the same effects as described above are obtained.

[0053] Fig. 13 shows a section of the vicinity of the first portion 151a of the frame body of the solid-state laser device in a second modification example. In this modification example, as in the first modification example, a cylindrical through hole 142 formed in the insulating member 123 constitutes a duct. In the second modification example, the diameter of the through hole (duct) 142 is sufficiently greater than the diameter of the light beam emitted from the laser rod 111, and the central axis of the light beam passing through the duct 142 is deviated in the direction of the first portion 151a of the frame body of the laser chamber from the central axis of the cylindrical duct 142. The deviation between the central axis of the duct 142 and the central axis is set to at least 1 mm, for example, about 2 mm. In this way, the central axis of the duct 142 is deviated from the central axis of laser light, whereby it is possible to provide a margin to optical path adjustment compared to a case where both central axes match each other.

[0054] Subsequently, a photoacoustic measurement device including the solid-state laser device of the invention will be described. Fig. 14 shows a photoacoustic measurement device including the solid-state laser device 100. The photoacoustic measurement device 10 comprises an ultrasound probe (probe) 11, an ultrasound unit 12, and the solid-state laser device 100. In the embodiment of the invention, although an ultrasonic wave is used as an acoustic wave, the invention is not limited to the ultrasonic wave, and an acoustic wave having an audio frequency may be used as long as an appropriate frequency has to be selected according to an inspection target, the measurement conditions, or the like.

[0055] Laser light emitted from the solid-state laser device 100 is guided to the probe 11, for example, using light guide means, such as an optical fiber, and is irradiated from the probe 11 toward a subject. The irradiation position of laser light is not particularly limited, and the irradiation of laser light may be performed from a place other than the probe 11.

[0056] Inside the subject, an optical absorber absorbs energy of irradiated laser light, and thus, an ultrasonic wave (acoustic wave) is generated. The probe 11 is acoustic wave detection means, and has, for example, a plurality of ultrasonic transducers arranged in a one-dimensional manner. The probe 11 detects an acoustic wave (photoacoustic wave) from the inside of the subject by a plurality of ultrasonic transducers arranged in a one-dimensional manner. The probe 11 transmits an acoustic wave (ultrasonic wave) to the subject and receives a reflected acoustic wave (reflected ultrasonic wave) of the transmitted ultrasonic wave from the inside of the subject.

[0057] The ultrasound unit 12 is signal processing means. The ultrasound unit 12 has a reception circuit 21, AD conversion means 22, a reception memory 23, data separation means 24, photoacoustic image generation means 25, ultrasound image generation means 26, image synthesis means 27, control means 28, and a transmission control circuit 29.

[0058] The reception circuit 21 receives a detection signal of the photoacoustic wave detected by the probe 11. Furthermore, the reception circuit 21 receives a detection signal of the reflected ultrasonic wave detected by the probe 11. The AD conversion means 22 converts the detection signals of the photoacoustic wave and the reflected ultrasonic wave received by the reception circuit 21 to digital signals. The AD conversion means 22 samples the detection signals of the photoacoustic wave and the reflected ultrasonic wave based on, for example, a sampling clock signal having a predetermined period. The AD conversion means 22 stores the sampled detection signals (sampling data) of the photoacoustic wave and the reflected ultrasonic wave in the reception memory 23.

[0059] The data separation means 24 separates sampling data of the detection signal of the photoacoustic wave stored in the reception memory 23 from sampling data of the detection signal of the reflected ultrasonic wave. The data separation means 24 inputs sampling data of the detection signal of the photoacoustic wave to the photoacoustic image generation means 25. Furthermore, the data separation means 24 inputs the separated sampling data of the reflected ultrasonic wave to the ultrasound image generation means (reflected acoustic image generation means) 26.

[0060] The photoacoustic image generation means 25 generates a photoacoustic image based on the detection signal of the photoacoustic wave detected by the probe 11. The generation of the photoacoustic image includes, for example, image reconstruction, such as phase matching addition, detection, logarithmic conversion, and the like. The ultrasound image generation means 26 generates an ultrasound image (reflected acoustic image) based on the detection signal of the reflected ultrasonic wave detected by the probe 11. The generation of the ultrasound image includes image reconstruction, such as phase matching addition, detection, logarithmic conversion, and the like.

[0061] The image synthesis means 27 synthesizes the photoacoustic image and the ultrasound image. For example, the image synthesis means 27 performs image synthesis by superimposing the photoacoustic image and the ultrasound image. A synthesized image is displayed on image display means 14, such as a display. Image synthesis may not be performed, and the photoacoustic image and the ultrasound image may be displayed in parallel on the image display means 14, or the photoacoustic image and the ultrasound image may be switched.

[0062] The control means 28 controls the respective units in the ultrasound unit 12. The control means 28 performs control for instructing the solid-state laser device 100 to emit light. For example, the control means 28 sends a trigger signal to the solid-state laser device 100. If the trigger signal is received, control means (not shown) in the solid-state laser device 100 turns on the flash lamp 112, and then, switches the Q value of the resonator from the low Q state to the high Q state with the Q switch 116 to emit pulse laser light. The control means 28 sends a sampling trigger signal to the AD conversion means 22 in conformity with the timing at which the subject is irradiated with light emitted from the solid-state laser device 100 and controls a sampling start timing of the photoacoustic wave.

[0063] The control means 28 sends an ultrasonic transmission trigger signal to instruct the transmission control circuit 29 to transmit the ultrasonic wave at the time of the generation of the ultrasound image. If the ultrasonic transmission trigger signal is received, the transmission control circuit 29 allows the ultrasonic wave to be transmitted from the probe 11. The control means 28 sends the sampling trigger signal to the AD conversion means 22 according to the ultrasonic transmission timing, and starts the sampling of the reflected ultrasonic wave.

[0064] In the above description, although a case where the probe 11 detects both the photoacoustic wave and the reflected ultrasonic wave in the photoacoustic measurement device 10 has been described, the probe for use in generating the ultrasound image and the probe for use in generating the photoacoustic image may not necessarily be the same. The photoacoustic wave and the reflected ultrasonic wave may be respectively detected by different probes. Furthermore, in the foregoing embodiments, although an example where the solid-state laser device constitutes a part of the photoacoustic measurement device has been described, the solid-state laser device of the invention may be used for a device different from the photoacoustic measurement device.

[0065] Although the invention has been described based on the preferred embodiment, the solid-state laser device and the photoacoustic measurement device of the invention are not limited to the foregoing embodiments, and various alterations may be carried out from the configurations of the foregoing embodiments which fall within the scope of the invention which is defined by the claims.

Explanation of References

[0066]

100:	solid-state laser device
111:	laser rod
112:	flash lamp
113:	laser chamber
114, 115:	mirror
116:	Q switch
117:	prism
118:	housing
119:	shielding lid
120:	thin film portion
121:	insulating block
123:	insulating member
124:	thin film
141, 142:	duct
131, 132:	hole portion
133:	O ring attachment portion
134:	O ring
151:	frame body
155:	diffusion material
156:	glass material
157,	158: storage hole
230:	cooling equipment
231, 232:	piping
10:	photoacoustic measurement device
11:	probe
12:	ultrasound unit
14:	image display means

21: reception circuit
22: AD conversion means
23: reception memory
24: data separation means
25: photoacoustic image generation means
26: ultrasound image generation means
27: image synthesis means
28: control means
29: transmission control circuit

Claims

1. A solid-state laser device comprising:

a laser rod (111);
an excitation lamp (112) which emits excitation light to the laser rod;
a laser chamber (113) which includes a frame body (151) having an internal space storing the laser rod and the excitation lamp and transmits light emitted from the excitation lamp (112) to the laser rod inside the frame body, a first portion (151a) of the frame body storing the excitation lamp having a first longitudinally extending hole portion (132) having a diameter greater than the outer diameter of the excitation lamp and a second portion (151b) of the frame body storing the laser rod having a second longitudinally extending hole portion (131) into which the laser rod is inserted;
a pair of mirrors (114, 115) provided outside the laser chamber on the optical path of a light beam emitted from the laser rod (111);
a boxlike housing (118) to which the laser chamber and the pair of mirrors (114, 115) are attached; and
a shielding lid (119) of the housing which surrounds said first portion (151a) of the frame body such that said first portion (151a) projects above a portion of the shielding lid (119) closest to the first portion (151a) of the frame body and which shields the internal space of the housing including the second portion of the frame body of the laser chamber attached to the housing (118), the pair of mirrors (114, 115), and the optical path of the light beam emitted from the laser rod (111) from the outside,
wherein the first portion of the frame body of the laser chamber further has an O ring attachment portion (133) in which an O ring (134) having an outer diameter greater than the diameter of the first hole portion (132) is attached at an end portion of the first portion of the frame body of the laser chamber in a longitudinal direction, the excitation lamp (112) is able to be removed from and inserted into the laser chamber intermediated by the first hole portion (132), and the thickness of a thin film first region (120) of the shielding lid (119) covering at least part of the optical path of the light beam emitted from the second hole portion (131) is smaller than the thickness of a second region of the shielding lid (119) which is further away than the first region from said first portion (151a) of the frame body in the longitudinal direction extending from the first portion (151a) of the frame body of the laser chamber to a side wall of the housing.

2. The solid-state laser device according to claim 1, further comprising an insulating member (123) which has a duct (141, 142), through which the light beam emitted from the laser rod (111) passes, and the laser chamber (113) is attached to the housing (118) intermediated by the insulating member (123), wherein the shielding lid (119) includes a plate-shaped lid portion (119a) which has an opening wider than the laser chamber (113) and the insulating member (123) closes the opening of the plate-shaped lid portion.

3. The solid-state laser device according to claim 2, wherein the first portion (151a) of the frame body (151) of the laser chamber (113) is exposed from the insulating member (123).

4. The solid-state laser device according to claim 2 or 3, wherein the duct (141, 142) is a through hole formed in the insulating member (123), and the thickness of a thin film (124) of the insulating member (123) which separates the outside on the first portion side of the frame body (151) from the through hole is smaller than the thickness of the plate-shaped lid portion.

5. The solid-state laser device according to claim 4, wherein the duct (142) has a cylindrical shape, the diameter of the cylindrical duct is greater than the diameter of the light beam emitted from the laser rod, and the central axis of the light beam passing through the cylindrical duct is deviated in the direction of the first portion of the frame body of the laser chamber (113) from the central axis of the cylindrical duct (142).

6. The solid-state laser device according to claim 2 or 3, wherein the duct (141) is a groove which is formed in the insulating member (123) and has an opening in the direction of the first portion (151a) of the frame body (151) of the laser chamber (113), the shielding lid further has a film which covers the opening of the duct, and the thickness of the film is smaller than the thickness of the plate-shaped lid portion.

7. The solid-state laser device according to claim 1, wherein the shielding lid is constituted of a plate-shaped lid portion, and of the plate-shaped lid portion, the thickness of at least a part of a region covering the optical path of the light beam emitted from the second hole portion is smaller than the thickness of other portions of the plate-shaped lid portion on the outside in the longitudinal direction from the first portion of the frame body of the laser chamber.

8. The solid-state laser device according to any one of claims 2 to 7,
wherein the frame body (151) is formed of a metal material.

9. The solid-state laser device according to claim 8, further comprising:
an insulating block (121) which is detachably attached to the first portion (151a) of the frame body of the laser chamber intermediated by the O ring.

10. The solid-state laser device according to any one of claims 1 to 9,
wherein the length in the longitudinal direction of the first portion (151a) of the frame body (151) is longer than the length in the longitudinal direction of the second portion (151b) of the frame body.

11. The solid-state laser device according to any one of claims 1 to 10,
wherein the laser chamber further has, in the internal space of the frame body, a glass material which has a first storage hole having an inner diameter greater than the outer diameter of the excitation lamp and storing the excitation lamp, and a second storage hole having an inner diameter greater than the outer diameter of the laser rod and storing the laser rod therein.

12. A photoacoustic measurement device comprising:

the solid-state laser device according to any one of claims 1 to 11;
photoacoustic wave detection means for detecting a photoacoustic wave generated in a subject after the subject has been irradiated with laser light emitted from the solid-state laser device; and
signal processing means for carrying out signal processing based on the detected photoacoustic wave.

Patentansprüche

1. Festkörperlaservorrichtung, umfassend:

einen Laserstab (111);
eine Anregungslampe (112), die Anregungslicht auf den Laserstab emittiert;
eine Laserkammer (113), die einen Rahmenkörper (151) mit einem einen Laserstab und die Anregungslampe aufnehmenden Innenraum enthält und von der Anregungslampe (112) emittiertes Licht zu dem im Inneren des Rahmenkörpers befindlichen Laserstab überträgt, wobei ein erster Abschnitt (151a) des Rahmenkörpers die Anregungslampe mit einem ersten, sich in Längsrichtung erstreckenden Lochabschnitt (132) aufnimmt, dessen Durchmesser größer ist als der Außendurchmesser der Anregungslampe, und ein zweiter Abschnitt (151b) des Rahmenkörpers den Laserstab mit einem zweiten, sich in Längsrichtung erstreckenden Lochabschnitt (131) aufnimmt, in den der Laserstab eingesetzt ist;
ein Paar Spiegel (114, 115) außerhalb der Laserkammer auf dem optischen Pfad des von dem Laserstab (111) emittierten Laserstrahls;
ein kastenförmiges Gehäuse (118), an welchem die Laserkammer und das Paar Spielgel (114, 115) angebracht sind; und
einen Abschirmdeckel (119) des Gehäuses, der den ersten Abschnitt (151a) des Rahmenkörpers derart umgibt, dass der erste Abschnitt (151a) oberhalb eines Abschnitts des Abschirmdeckels (119) vorsteht, der dem ersten Abschnitt (151) des Rahmenkörpers am Nächsten liegt, und der den Innenraum des Gehäuses einschließlich des zweiten Abschnitts des Rahmenkörpers der Laserkammer, angebracht an dem Gehäuse (118), das Paar von Spiegeln (114, 115) und den optischen Pfad des von dem Laserstab (111) emittierten Lichtstrahls von außen abschirmt,
wobei der erste Abschnitt des Rahmenkörpers der Laserkammer weiterhin einen O-Ring-Befestigungsabschnitt (133) enthält, in welchem ein O-Ring (134) mit einem Außendurchmesser größer als der Durchmesser des ersten Lochabschnitts (132) an einem Endabschnitt des ersten Abschnitts des Rahmenkörpers der Laserkammer in Längsrichtung gesehen angebracht ist, die Anregungslampe (112) aus der Laserkammer über den ersten Lochabschnitt (132) entfernt und über diesen in die Laserkammer eingeführt werden kann, und die Dicke einer dünnschichtigen ersten Zone (120) des Abschirmdeckels (119), die mindestens einen Teil des optischen Wegs des von dem zweiten Lochabschnitt (131) emittierten Laserstrahls abdeckt, kleiner ist als die Dicke einer zweiten Zone des Abschirmdeckels (119), die weiter entfernt ist als die erste Zone von dem ersten Abschnitt (151a) des Rahmenkörpers in der Längsrichtung, die sich von dem ersten Abschnitt (151a) des Rahmenkörpers der Laserkammer zu einer Seitenwand des Gehäuses erstreckt.

2. Festkörperlaservorrichtung nach Anspruch 1, weiterhin umfassend
ein Isolierelement (123) mit einem Kanal (141, 142), durch den hindurch der von dem Laserstrahl (111) emittierte Lichtstrahl läuft, wobei die Laser (113) an dem Gehäuse (118) über das Isolierelement (123) befestigt ist, und der Abschirmdeckel (119) einen plattenförmigen Deckelabschnitt (119a) mit einer Öffnung breiter als die Laserkammer (113) enthält und das Isolierelement (123) die Öffnung des plattenförmigen Deckelabschnitts verschließt.

3. Festkörperlaservorrichtung nach Anspruch 2,
wobei der erste Abschnitt (151a) des Rahmenkörpers (151) der Laserkammer (113) gegenüber dem Isolierelement (123) freiliegt.

4. Festkörperlaservorrichtung nach Anspruch 2 oder 3,
bei der der Kanal (141, 142) ein in dem Isolierelement (123) ausgebildetes Durchgangsloch ist, und die Dicke einer Dünnschicht (124) des Isolierelements (123), welche die Außenseite auf der Seite des ersten Abschnitts des Rahmenkörpers (151) von dem Durchgangsloch trennt, kleiner ist als die Dicke des plattenförmigen Deckelabschnitts.

5. Festkörperlaservorrichtung nach Anspruch 4,
bei der der Kanal (142) eine zylindrische Form aufweist, deren Durchmesser größer ist als der Durchmesser des von dem Laserstab emittierten Lichtstrahls, und die Mittelachse des durch den zylindrischen Kanal laufenden Lichtstrahls in der Richtung des ersten Abschnitts des Rahmenkörpers der Laserkammer (113) von der Mittelachse des zylindrischen Kanals (142) abgelenkt ist.

6. Festkörperlaservorrichtung nach Anspruch 2 oder 3,
bei der der Kanal (141) eine in dem Isolierelement (123) ausgebildete Nut ist und eine Öffnung in der Richtung des ersten Abschnitts (151a) des Rahmenkörpers (151) der Laserkammer (113) besitzt, wobei der Abschirmdeckel weiterhin eine die Öffnung des Kanals bedeckende Dünnschicht aufweist und die Dicke der Dünnschicht kleiner ist als die Dicke des plattenförmigen Deckelabschnitts.

7. Festkörperlaservorrichtung nach Anspruch 1,
bei der der Abschirmdeckel durch einen plattenförmigen Deckelabschnitt gebildet ist, und von dem plattenförmigen Deckelabschnitt die Decke mindestens eines Teils einer den optischen Pfad des von dem zweiten Lochabschnitt emittierten Lichtsstrahls abdeckenden Zone kleiner ist als die Dicke der übrigen Abschnitte des plattenähnlichen Deckelabschnitts auf der Außenseite in Längsrichtung von dem ersten Abschnitt des Rahmenkörpers der Laserkammer.

8. Festkörperlaservorrichtung nach einem der Ansprüche 2 bis 7,
bei der der Rahmenkörper (151) aus metallischem Werkstoff gebildet ist.

9. Festkörperlaservorrichtung nach Anspruch 8, weiterhin umfassend:
einen Isolierblock (121), der lösbar an dem ersten Abschnitt (151a) des Rahmenkörpers der Laserkammer über den O-Ring angebracht ist.

10. Festkörperlaservorrichtung nach einem der Ansprüche 1 bis 9,
bei der die Länge in der Längsrichtung des ersten Abschnitts (151a) des Rahmenkörpers (151) größer ist als die Länge in der Längsrichtung des zweiten Abschnitts (151b) des Rahmenkörpers.

11. Festkörperlaservorrichtung nach einem der Ansprüche 1 bis 10,
bei der die Laserkammer innerhalb des Innenraums des Rahmenkörpers außerdem ein Glasmaterial aufweist, welches ein erstes Aufnahmeloch mit einem Innendurchmesser größer als der Außendurchmesser der Anregungslampe aufweist, das die Anregungslampe aufnimmt, und ein zweites Aufnahmeloch mit einem Innendurchmesser größer als der Außendurchmesser des Laserstabs aufweist, welches in sich den Laserstab aufnimmt.

12. Photoakustische Messvorrichtung, umfassend:

eine Festkörperlaservorrichtung nach einem der Ansprüche 1 bis 11;
eine photoakustische Wellendetektoreinrichtung zum Detektieren einer photoakustischen Welle, die in einem Objekt erzeugt wird, nach dem dieses mit von der Festkörperlaservorrichtung emittierte Laserlicht bestrahlt wurde; und
eine Signalverarbeitungseinrichtung zum Ausführen einer Signalverarbeitung basierend auf der detektierten photoakustischen Welle.

Revendications

1. Dispositif laser à solide, comprenant :

un barreau laser (111) ;
une lampe d'excitation (112), laquelle émet une lumière d'excitation vers le barreau laser ;
une chambre laser (113), laquelle inclut un corps de bâti (151) présentant un espace interne stockant le barreau laser et la lampe d'excitation, et transmet une lumière émise à partir de la lumière d'excitation (112) vers le barreau laser dans le corps de bâti, une première portion (151a) du corps de bâti stockant la lampe d'excitation pré-

sentant une première portion de trou s'étendant de manière longitudinale (132) présentant un diamètre plus grand que le diamètre extérieur de la lampe d'excitation, et une seconde portion (151b) du corps de bâti stockant le barreau laser présentant une seconde portion de trou s'étendant de manière longitudinale (131) dans laquelle le barreau laser est introduit ;

une paire de miroirs (114, 115) prévue hors de la chambre laser sur le trajet optique d'un faisceau lumineux émis à partir du barreau laser (111) ;

un logement de type boîtier (118) sur lequel la chambre laser et la paire de miroirs (114, 115) sont fixées, et

un couvercle de blindage (119) du logement, lequel entoure ladite première portion (151a) du corps de bâti de telle sorte que ladite première portion (151a) fait saillie au-dessus d'une portion du couvercle de blindage (119) la plus proche de la première portion (151a) du corps de bâti, et lequel fait écran pour l'espace interne du logement incluant la seconde portion du corps de bâti de la chambre laser fixée sur le logement (118), la paire de miroirs (114, 115), et le trajet optique du faisceau lumineux émis à partir du barreau laser (111), contre l'extérieur ;

dans lequel la première portion du corps de bâti de la chambre laser présente en outre une portion de fixation à joint torique (133), où un joint torique (134) présentant un diamètre extérieur plus grand que le diamètre de la première portion de trou (132) est fixé sur une portion d'extrémité de la première portion du corps de bâti de la chambre laser dans une direction longitudinale ; la lampe d'excitation (112) peut être retirée de la chambre laser, et introduite dans celle-ci, par l'intermédiaire de la première portion de trou (132), et l'épaisseur d'une première région à couche mince (120) du couvercle de blindage (119) couvrant au moins une partie du trajet optique du faisceau lumineux émis à partir de la seconde portion de trou (131) est inférieure à l'épaisseur d'une seconde région du couvercle de blindage (119), lequel est plus éloigné de la première région que ladite première portion (151a) du corps de bâti dans la direction longitudinale s'étendant de la première portion (151a) du corps de bâti de la chambre laser à une paroi latérale du logement.

2. Dispositif laser à solide selon la revendication 1, comprenant en outre :

un élément isolant (123), lequel présente un conduit (141, 142), à travers lequel passe le faisceau lumineux émis à partir du barreau laser (111), et la chambre laser (113) est fixée sur le logement (118) par l'intermédiaire de l'élément isolant (123),

dans lequel le couvercle de blindage (119) inclut une portion de couvercle en forme de plaque (119a), laquelle présente une ouverture plus large que la chambre laser (113) et l'élément isolant (123) ferme l'ouverture de la portion de couvercle en forme de plaque.

3. Dispositif laser à solide selon la revendication 2, dans lequel la première portion (151a) du corps de bâti (151) de la chambre laser (113) est exposée à partir de l'élément isolant (123).

4. Dispositif laser à solide selon la revendication 2 ou 3, dans lequel le conduit (141, 142) est un trou débouchant formé dans l'élément isolant (123), et l'épaisseur d'une couche mince (124) de l'élément isolant (123), lequel sépare l'extérieur sur le côté de première portion du corps de bâti (151) du trou débouchant, est inférieure à l'épaisseur de la portion de couvercle en forme de plaque.

5. Dispositif laser à solide selon la revendication 4, dans lequel le conduit (142) présente une forme cylindrique ; le diamètre du conduit cylindrique est plus grand que le diamètre du faisceau lumineux émis à partir du barreau laser, et l'axe central du faisceau lumineux traversant le conduit cylindrique est dévié dans la direction de la première portion du corps de bâti de la chambre laser (113) à partir de l'axe central du conduit cylindrique (142).

6. Dispositif laser à solide selon la revendication 2 ou 3, dans lequel le conduit (141) est une rainure, laquelle est formée dans l'élément isolant (123) et présente une ouverture dans la direction de la première portion (151a) du corps de bâti (151) de la chambre laser (113) ; le couvercle de blindage présente un outre un film, lequel couvre l'ouverture du conduit, et l'épaisseur du film est inférieure à l'épaisseur de la portion de couvercle en forme de plaque.

7. Dispositif laser à solide selon la revendication 1, dans lequel le couvercle de blindage est constitué d'une portion de couvercle en forme de plaque, et, de la portion de couvercle en forme de plaque, l'épaisseur d'au moins une partie d'une région couvrant le trajet optique du faisceau lumineux émis à partir de la seconde portion de trou est inférieure à l'épaisseur d'autres portions de la portion de couvercle en forme de plaque sur l'extérieur dans la direction longitudinale à partir de la première portion du corps de bâti de la chambre laser.

8. Dispositif laser à solide selon l'une quelconque des revendications 2 à 7,
dans lequel le corps de bâti (151) est formé d'un

matériau métallique.

9. Dispositif laser à solide selon la revendication 8, comprenant en outre :
un bloc isolant (121), lequel est fixé de manière à pouvoir être détaché sur la première portion (151a) du corps de bâti de la chambre laser par l'intermédiaire du joint torique.

10. Dispositif laser à solide selon l'une quelconque des revendications 1 à 9,
dans lequel la longueur dans la direction longitudinale de la première portion (151a) du corps de bâti (151) est plus longue que la longueur dans la direction longitudinale de la seconde portion (151b) du corps de bâti.

11. Dispositif laser à solide selon l'une quelconque des revendications 1 à 10,
dans lequel la chambre laser présente en outre, dans l'espace interne du corps de bâti, un matériau en verre, lequel présente un premier trou de stockage présentant un diamètre intérieur plus grand que le diamètre extérieur de la lampe d'excitation, et stockant la lampe d'excitation, et un second trou de stockage présentant un diamètre intérieur plus grand que le diamètre extérieur du barreau laser et stockant à l'intérieur le barreau laser.

12. Dispositif de mesure photoacoustique, comprenant :

le dispositif laser à solide selon l'une quelconque des revendications 1 à 11,
un moyen de détection d'onde photoacoustique pour détecter une onde photoacoustique générée dans un sujet après irradiation du sujet avec la lumière laser émise à partir du dispositif laser à solide, et
un moyen de traitement de signaux pour mettre en œuvre le traitement de signaux sur la base de l'onde photoacoustique détectée.

FIG. 1

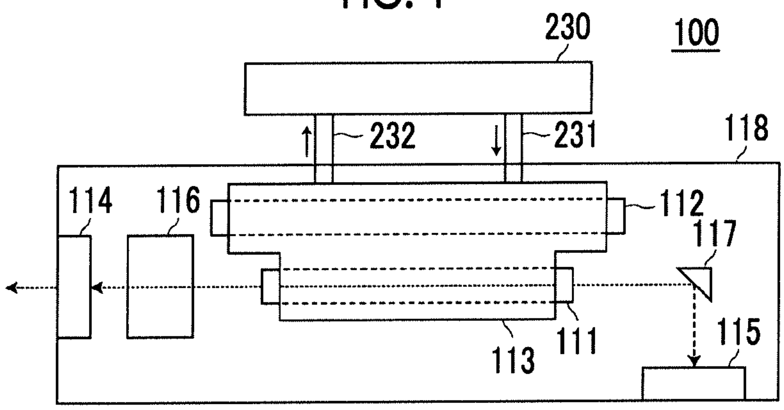


FIG. 2

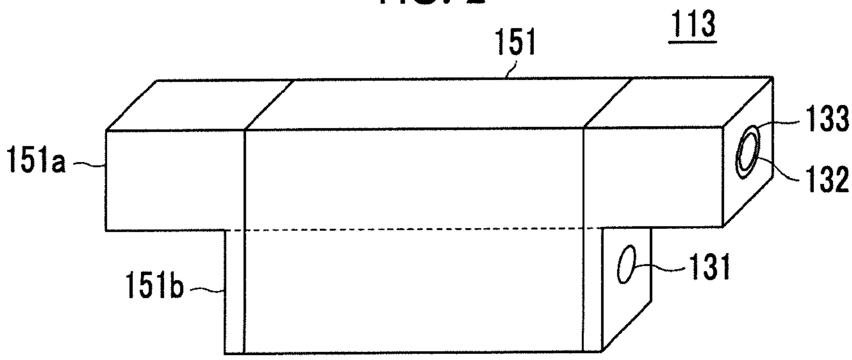


FIG. 3

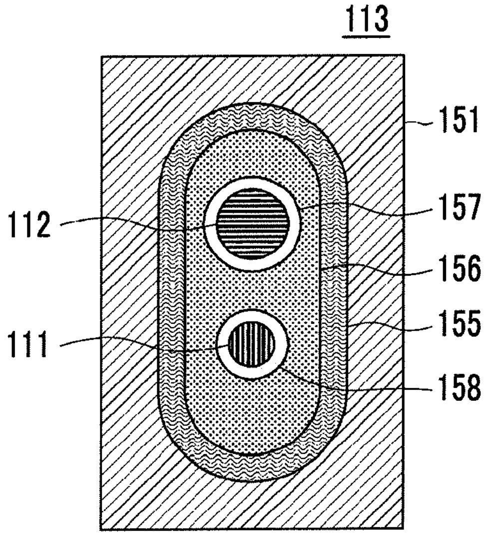


FIG. 4

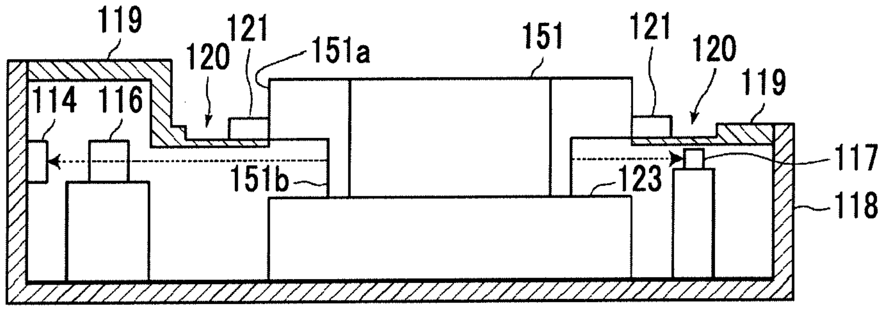


FIG. 5

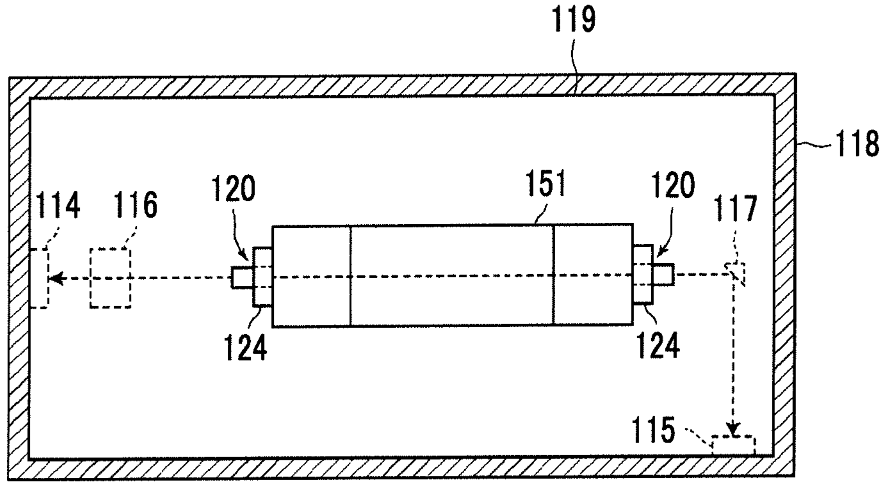


FIG. 6

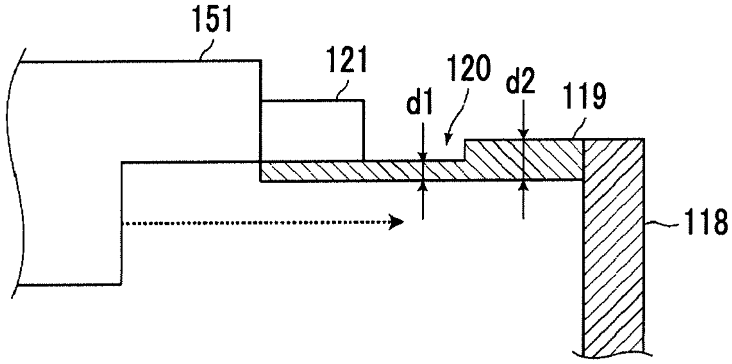


FIG. 7

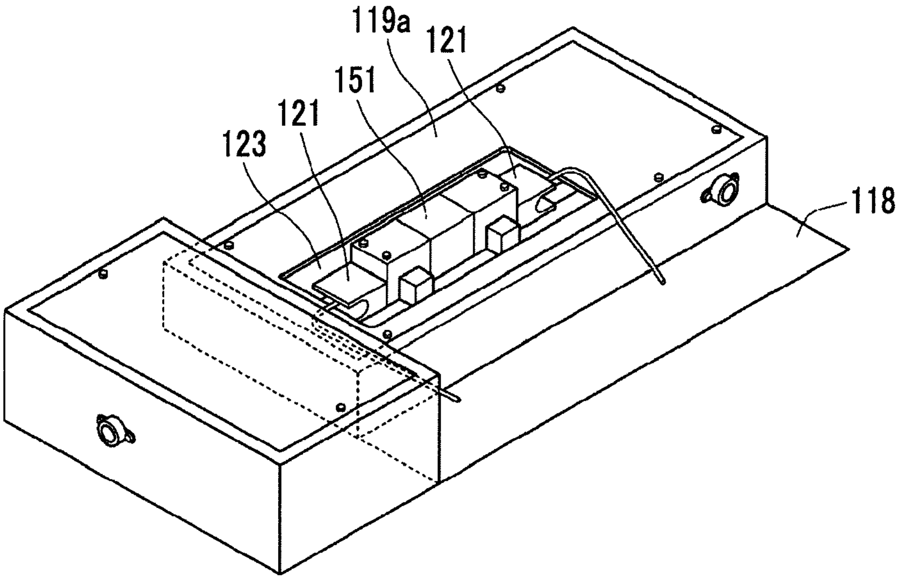


FIG. 8

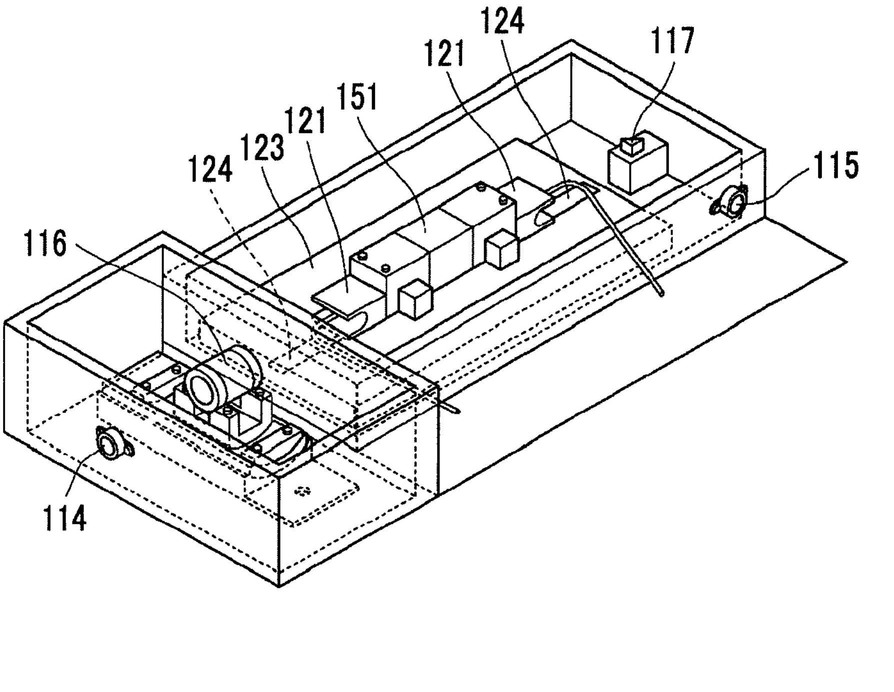


FIG. 9

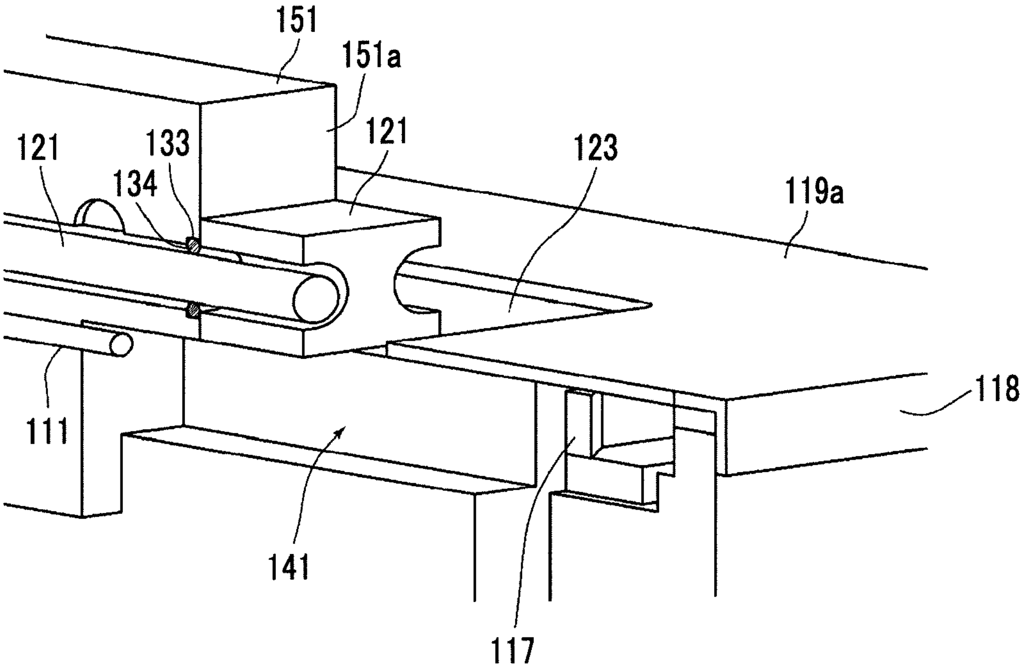

151
151a
121
133
121
123
134
119a
118
111
141
117

FIG. 10

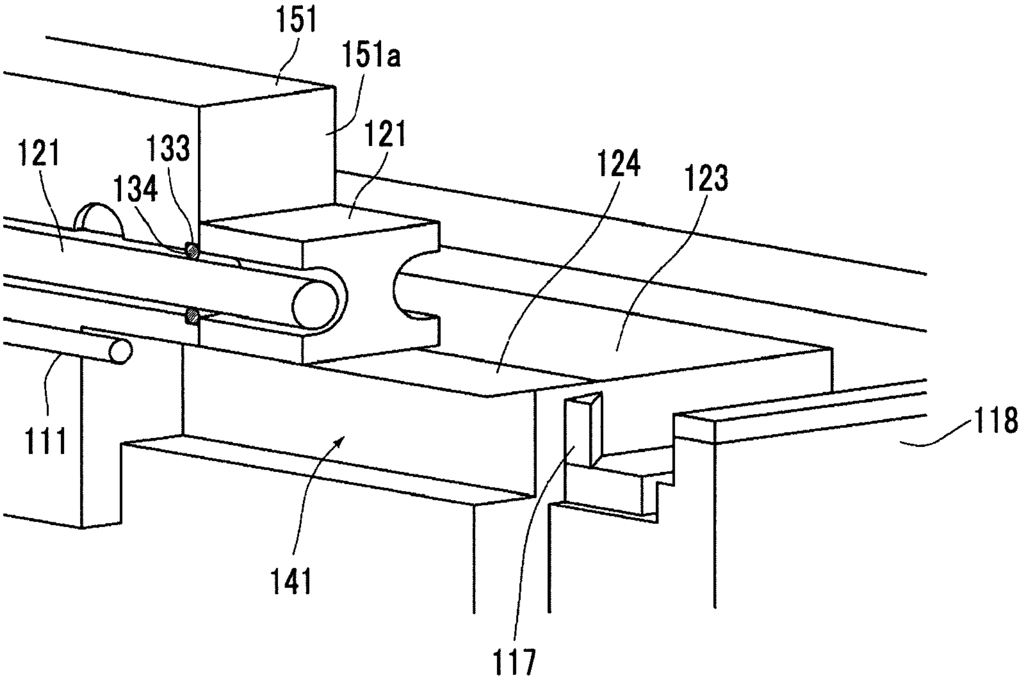

151
151a
121
133
121
124
123
134
118
111
141
117

FIG. 11

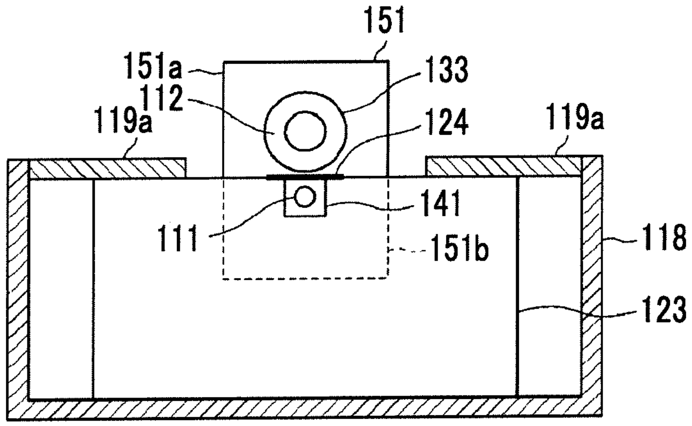


FIG. 12

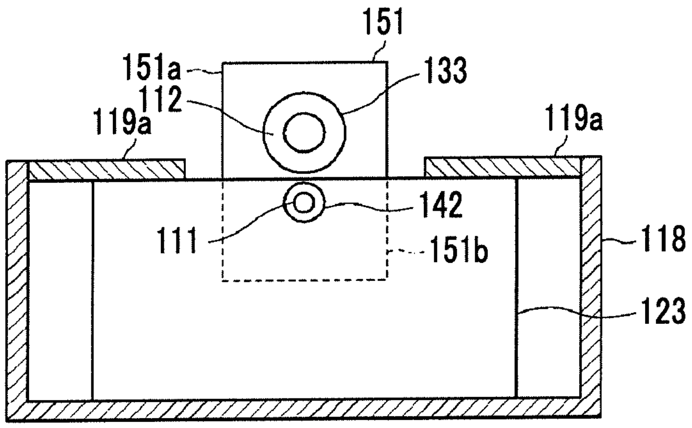


FIG. 13

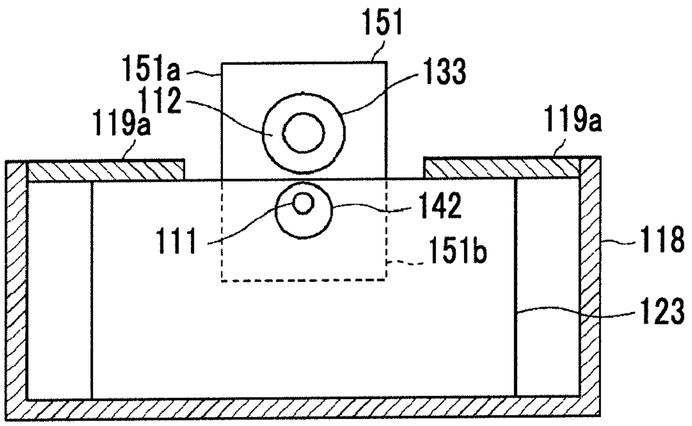
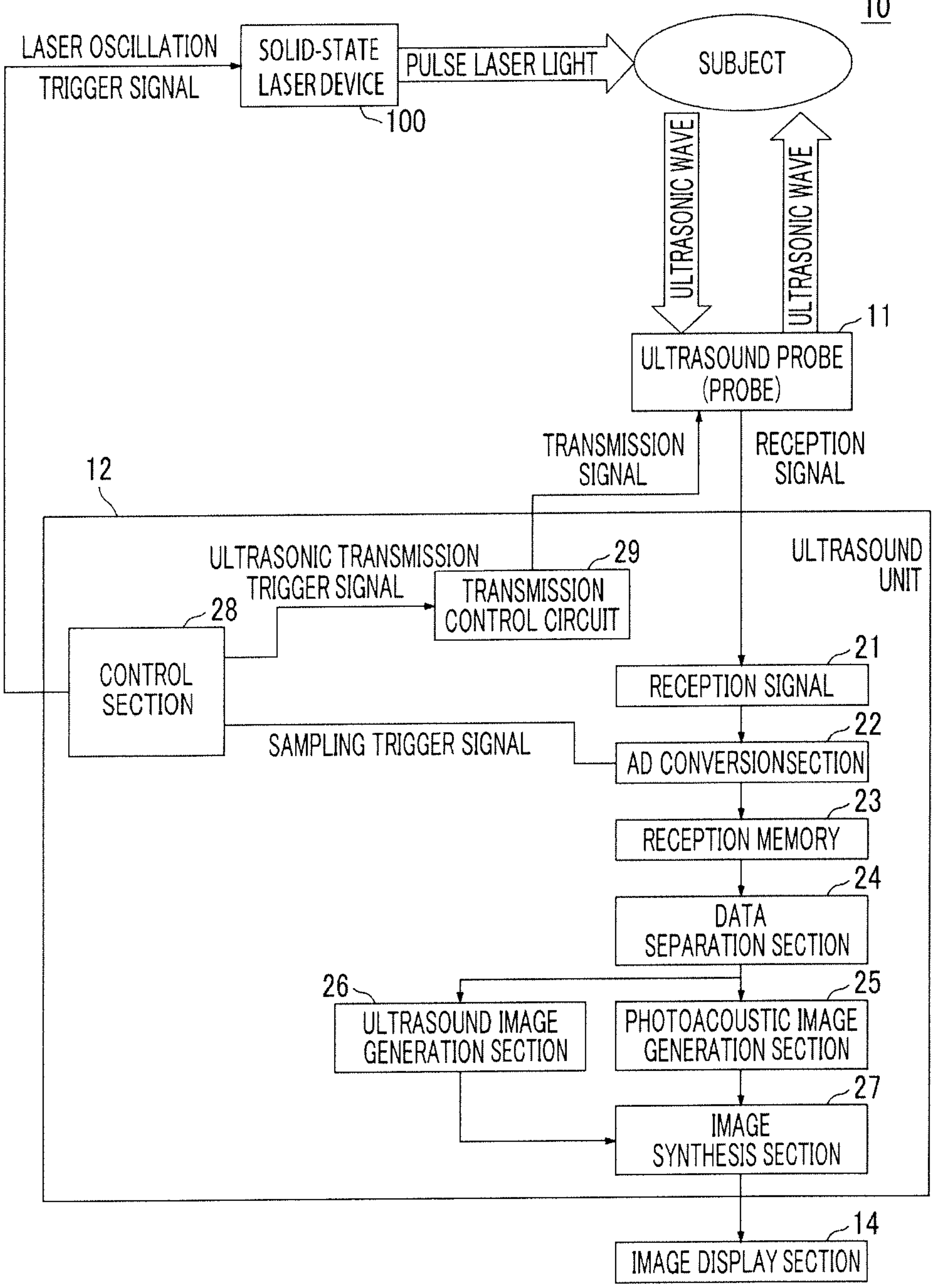


FIG. 14


10
LASER OSCILLATION TRIGGER SIGNAL
SOLID-STATE LASER DEVICE
100
PULSE LASER LIGHT
SUBJECT
ULTRASONIC WAVE
ULTRASONIC WAVE
11
ULTRASOUND PROBE (PROBE)
TRANSMISSION SIGNAL
RECEPTION SIGNAL
12
ULTRASOUND UNIT
ULTRASONIC TRANSMISSION TRIGGER SIGNAL
29
TRANSMISSION CONTROL CIRCUIT
28
CONTROL SECTION
21
RECEPTION SIGNAL
SAMPLING TRIGGER SIGNAL
22
AD CONVERSIONSECTION
23
RECEPTION MEMORY
24
DATA SEPARATION SECTION
26
ULTRASOUND IMAGE GENERATION SECTION
25
PHOTOACOUSTIC IMAGE GENERATION SECTION
27
IMAGE SYNTHESIS SECTION
14
IMAGE DISPLAY SECTION

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6260701 A **[0006]**
- JP H06260701 A **[0006]**

patsnap

专利名称(译)	固态激光装置和光声测量装置		
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IPC分类号	H01S3/092 A61B8/00 A61B5/00 G01N29/00 H01S3/093 H01S3/06 H01S3/02 H01S3/04		
CPC分类号	A61B5/0095 H01S3/025 H01S3/0407 H01S3/061 H01S3/0931 H01S3/093		
优先权	2014068538 2014-03-28 JP		
其他公开文献	EP3125377A1 EP3125377A4		
外部链接	Espacenet		

摘要(译)

在固态激光装置和包括该固态激光装置的光声测量装置中，激光棒中心与闪光灯中心之间的距离变窄。 遮蔽盖119遮蔽反射镜114和115或来自外部的激光的光路。 激光室的框架主体的第一部分151a从屏蔽盖119暴露。能够从框架的第一部分151a移除并插入到激光室的框架主体151中的闪光灯。 身体。 在遮蔽盖的外侧，在覆盖从激光棒射出的光束的光路的区域的至少一部分中，设置有比遮蔽盖119的其他部分的厚度小的厚度的薄膜部120。 从激光腔室的框架主体的第一部分151a开始沿纵向方向119形成。