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

(11) EP 2 948 041 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
13.03.2019 Bulletin 2019/11

(21) Application number: **14700791.8**

(22) Date of filing: **20.01.2014**

(51) Int Cl.:
A61B 5/00 *(2006.01)* ***A61B 5/055*** *(2006.01)*
A61B 10/02 *(2006.01)*

(86) International application number:
PCT/GB2014/050147

(87) International publication number:
WO 2014/114921 (31.07.2014 Gazette 2014/31)

(54) **OPTICAL APPARATUS FOR USE WITH A MEDICAL IMAGER**

OPTISCHE VORRICHTUNG ZUR VERWENDUNG MIT EINER MEDIZINISCHEN BILDGEBUNGSVORRICHTUNG

APPAREIL OPTIQUE DESTINÉ À ÊTRE UTILISÉ AVEC UN DISPOSITIF D'IMAGERIE MÉDICALE

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

(30) Priority: **24.01.2013 GB 201301280**

(43) Date of publication of application:
02.12.2015 Bulletin 2015/49

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EP 2 948 041 B1

Description

Introduction

[0001] The present invention relates to an optical apparatus and method for use with a medical imager. In particular, the invention relates to an apparatus for performing Raman spectroscopy in conjunction with a magnetic resonance imaging scanner.

Background

[0002] Since the advent of optical microscopy numerous technologies have been developed to obtain morphological and chemical information from tissue. This information plays a key role in disease diagnosis. The development of multimodal imaging and spectroscopic techniques, which combine two or more technologies, can provide complementary information from tissue and therefore enhance diagnosis.

[0003] Magnetic Resonance Imaging (MRI) is an established medical imaging modality, which is being widely used for visualizing internal body structures. MRI has a non-ionizing field that makes it ideal for interventional radiology. However, it remains difficult to implement various procedures with interventional MRI (iMRI), as specialized non-ferromagnetic equipment has to be designed to work in the strong static and dynamic magnetic field of the MRI scanner.

[0004] Raman spectroscopy is another powerful tool, which can be used for obtaining biochemical information of tissue. The technique is sensitive enough to detect minor changes in the tissue composition for distinguishing between normal and diseased tissue. There has been significant development in the field of fibre Raman probes, which now enables *in vivo* tissue analysis using endoscopic Raman probes.

[0005] Conventional fibre-Raman-probes have an excitation fibre channel and a Raman signal collection fibre channel. These channels are co-aligned at the tip of a probe head. Filters are included at the probe head to reduce fluorescence from the fibre. Such filters may include a line filter to filter out fluorescence background from the excitation fibre and an edge filter that filters out Rayleigh scattered light that would enter the collection channel. The filter assembly at the fibre probe head results in a relatively large probe head. In addition, all commercially available fibre probes comprise metallic ferrules to position micro-optic elements at the probe head.

[0006] WO2010122443 discloses a device for intervention in a high magnetic field comprises an elongate shaft with a tip portion, and a passive LC-circuit or a plurality of passive LC circuits positioned at the tip portion, wherein the LC-circuit is formed as an inductor-capacitor resonator. By the magnetic field of an MRI, the LC-circuit will be activated to oscillate. Said oscillation will result in a response magnetic field which in turn will be sensed by the MRI unit so that the LC-circuit and therefore the tip portion of the device is visible in the MRI-image. By way of this, the guiding of the device is facilitated.

[0007] WO2013/001394 discloses a system compatible with MRI. An insert with optical fibres for tissue illumination and light detection is inserted into a biopsy needle.

Summary of the invention

[0008] According to one aspect of the present invention, there is provided an optical apparatus comprising a disposable non-magnetic optical fibre probe for coupling light into a sample and receiving light from the sample, and a non-magnetic optical extension releasably connected to the disposable non-magnetic optical probe for transmitting light into the disposable non-magnetic optical probe and receiving light from the disposable non-magnetic optical probe, wherein the non-magnetic optical extension comprises:

a first optical extension fibre for transmitting light into the disposable non-magnetic optical probe;
a second optical extension fibre for receiving light from the disposable non-magnetic optical probe;
an excitation filter for filtering light from the first optical extension fibre; and
a collection filter for filtering light into the second optical extension fibre.

[0009] The disposable non-magnetic optical probe may be filterless.

[0010] By disposable it is meant, the probe is adapted for single use applications. After a single use, the probe is intended to be discarded. The disposable probe may be supplied in a sealed, sterile package.

[0011] The disposable non-magnetic optical probe may be adapted to be fitted in a non-magnetic biopsy needle. The non-magnetic biopsy needle may be provided as part of the optical apparatus.

[0012] The disposable non-magnetic optical probe may comprise a first optical fibre for coupling light into the sample and at least one second optical fibre for receiving light from the sample. The first and second fibres may be connected at one end to form a probe head. A first optical connector may be provided at another end of the first optical fibre. A second optical connector may be provided at another end of the second optical fibre, wherein the first and second connectors are connectable to the non-magnetic optical extension.

[0013] The first optical fibre may have a length less than a critical length to limit fluorescence generation upon optical excitation.

[0014] The tips of the first fibre and second fibre may be substantially aligned. Alternatively, the tips of the first and second fibres may be offset, for example the tip of the first fibre may protrude beyond the tip(s) of the second fibre(s) or the tip(s) of the second fibre(s) may protrude beyond the tip of the first fibre. The tips may be offset by

less than 10 mm. The offset may be arranged so that in use one of the first and second fibres is in contact with the sample and the other is not.

[0015] The first fibre and the second fibre may be substantially parallel in the probe head.

[0016] The first fibre and the second fibre may be separated, for example by a gap, in the probe head. The separation of the fibres or gap may be less than 1 mm.

[0017] Ideally, the probe head has a diameter less than or equal to 2 mm. The probe head may have at least one optical component, for example one or more lenses.

[0018] The non-magnetic optical extension may comprise a first optical coupler for coupling light into the disposable non-magnetic optical fibre probe and a second optical coupler for coupling light from the disposable non-magnetic optical fibre probe into the second optical extension fibre.

[0019] The non-magnetic optical extension may comprise at least one connector for releasably connecting the extension and the disposable non-magnetic optical probe.

[0020] The non-magnetic optical extension may comprise a housing and the first filter and the second filter may be arranged in the housing. The first optical coupler and the second optical coupler may be in the housing. Within the housing, the first filter and/or the first optical coupler may be optically isolated from the second filter and/or the second optical coupler.

[0021] The optical apparatus may have a total length greater than a critical length, for example greater than 5 m.

[0022] According to another aspect of the present invention, there is provided a system for performing optical spectroscopy comprising an imaging medical device having a patient area, and the optical apparatus connected to a light source and a detector, wherein the medical device and the optical apparatus are located in a first room or area and the light source and detector are located in a second room or area electromagnetically shielded from the first room or area.

[0023] The detector may comprise a Raman spectrometer.

[0024] The medical device may comprise an MRI scanner.

[0025] A disposable non-magnetic fibre based optical probe for use in a medical device is described herein. The disposable non-magnetic optical probe may be sterile and/or provided in a sterile package. The disposable non-magnetic optical probe may be filterless. The disposable non-magnetic optical probe may comprise a first optical fibre for coupling light into a sample and at least one second optical fibre for receiving light from the sample. A first optical connector may be provided at an end of the first optical fibre. A second optical connector may be provided at an end of the second optical fibre. The first optical fibre may have a length less than a critical length to limit fluorescence generation upon optical excitation. The probe may have a probe head. Preferably, the probe head has a a diameter less than or equal to 2 mm. The probe head may have at least one optical component, for example one or more lenses.

[0026] A medical system is described herein, the medical system comprising a medical device having a patient area, for example an imaging medical device, and an optical apparatus connected to a light source and a detector, wherein the medical device and the optical apparatus are located in a first room or area and the light source and detector are located in a second room or area electromagnetically shielded from the first. The electromagnetic shielding may include a Faraday cage. The medical device may be an MRI scanner. The light source may be a laser. The detector may include a spectrometer, for example a Raman spectrometer.

[0027] A method is described herein for performing optical spectroscopy measurements on a patient using a probe, a light source and a detector, whilst another medical device is being used, for example an imaging medical device, the method involving monitoring an area of the patient using the medical device and simultaneously moving the probe into the vicinity of the examination area, for example into contact with the examination area, illuminating the examination area using the probe and the light source, collecting light from the excitation area via the probe, and detecting collected light using the detector, wherein the medical device and the probe are located in a first room or area and the light source and detector are located in a second room or area electromagnetically shielded from the first. The medical device may be a MRI scanner. The optical spectroscopy may be Raman spectroscopy.

[0028] Bringing a probe head in contact with the examination area may involve inserting a catheter/needle into the area and introducing the probe head inside the catheter/needle.

[0029] A non-magnetic biopsy needle is described herein comprising an elongate tubular portion open at a first end and terminated at a second end by a cutting portion, a window on a wall of the tubular portion, a light reflector inside the tubular portion and optically aligned with the window. The tubular portion may be adapted to receive a disposable non-magnetic optical probe. A transparent sleeve may be located around the window. The window may be located in a region adjacent the cutting portion.

Brief Description of the Drawings

[0030] Various aspects of the invention will now be described by way of example only and with reference to the accompanying drawings, of which:

Figure 1 is a cross section of a disposable non-magnetic optical probe;

Figure 2 (a) is a cross section of a probe head comprising a single collection fibre;

Figure 2 (b) is a cross section of a probe head com-

prising five collection fibres;
Figure 2 (c) is an end view of the probe head of Figure 2 (b);
Figure 3 (a) is a cross section of a probe head comprising a single collection fibre wherein the excitation fiber is the contact fiber;
Figure 3 (b) is a cross section of a probe head comprising five collection fibres wherein the excitation fiber is the contact fiber;
Figure 3 (c) is an end view of the probe head of Figure 3 (b);
Figure 4 (a) is a cross section of a probe head comprising a single collection fibre wherein the collection fiber is the contact fiber;
Figure 4 (b) is a cross section of a probe head comprising five collection contact fibres;
Figure 4 (c) is an end view of the probe head of Figure 4 (b);
Figure 5 is a cross section of a probe head comprising an optical window;
Figure 6 is a cross section of a probe head comprising a GRIN lens;
Figure 7 is a cross section of a probe head comprising two microlenses;
Figure 8 is a cross section of a probe head comprising one microlens;
Figure 9 is a schematic representation of a system, comprising an apparatus which constitutes an embodiment of the present invention, for performing optical spectroscopy in an area where a magnetic field is applied;
Figure 10 (a) is a Raman signal of a paracetamol tablet obtained with the optical probe of Figure 1, and
Figure 10 (b) is a Raman signal of a bovine adipose tissue obtained with the optical probe of Figure 1.
Figure 11 is a profile sectional view of a non-magnetic optical biopsy needle.
Figure 12 is a photograph of the optical biopsy needle of Figure 11.

Detailed description of the invention

[0031] Figure 1 shows a disposable non-magnetic optical probe 10 that has an excitation fibre 12 and a collection fibre 14. At one end, the excitation fibre 12 and the collection fibre 14 are held together by a sleeve 16, such as a heat shrinkable sleeve to form a probe head 18 with a diameter D. Inside the probe head 18, the excitation fibre 12 and the collection fibre 14 are held parallel with their respective ends aligned so as to maximize collection efficiency. At the other end, both the excitation fibre 12 and the collection fibre 14 are terminated with a connector 15a and 15b, such as a SMA or FC-PC connector. All of the components of the probe 10 are non-magnetic. The disposable probe may be sterile and may be supplied in a sealed, sterile package (not shown).

[0032] The maximum length L of each fibre in the optical probe 10 is limited by a level of background fluorescence generated inside the excitation fibre 12 compared with a level of signal collected by the collection fibre 14. The fluorescence background is proportional to the level of attenuation of a given optical fibre, which itself varies with an absorption coefficient of the material of the fibre. In the case of a Raman signal emitted from a sample, the level of signal will depend on both the nature of the sample (different samples have different Raman cross sections) and the intensity of radiation used to illuminate the sample. For example, for a Raman measurement of adipose tissue acquired at 785 nm with 200mW excitation power and an acquisition time of 1s, the Raman signal was 100 counts for the Raman bands corresponding to methylene scissor deformations and the fluorescence background measured in the excitation optical fibre was 950 counts. In this case, to achieve a signal to background ratio of 0.1, a critical length of 1.5 m is needed. Typically, the fibres of the optical probe 10 have a length L ranging from 0.5 to 1.5 m.

[0033] Figure 2 shows two probe heads, one having a single collection fibre (a) and a second (b) having multiple collection fibres aligned around the excitation fibre, as shown in Figure 2 (c), and bundled together at the distal end opposite the probe head into an optical connector. The tip of the probe head could be polished or cleaved at an angle so that the excitation and collection cones are side looking. Such geometry could be useful when it is necessary to scan tissue surfaces when the probe is inserted into a tube like structure such as an artery.

[0034] Figure 3 (a) shows a probe head that has an excitation fibre 12 that is longer than the collection fibre 14, resulting in an excitation fibre 12 that protrudes beyond the tip of the collection fibre 14 at the end of the probe head. The distance between the tip of the excitation fibre and the tip of the collection fibre may be 3 to10 mm. In this case, the excitation fibre 12 is shown in contact with a sample 17. The collection fibre 14 is not in contact with the sample 17, but instead is spaced apart from the sample 17.

[0035] Figure 3 (b) shows a probe head having an excitation fibre surrounded by five collection fibres. In this example each one of the five collection fibres has a length that is shorter than the length of the central excitation fibre, resulting in an excitation fibre that protrudes at the tip of the probe head. The distance between the tip of the excitation fibre and the tip of the collection fibres may be in the range of 3 to 10 mm. In this case, the excitation fibre 12 is shown in contact with a sample 17. The collection fibres 14 are not in contact with the sample 17, but instead are all spaced apart from the sample 17.

[0036] Figure 4 (a) shows a probe head having an excitation fibre that is shorter than the collection fibre, resulting in a collection fibre that protrudes beyond the end of the excitation fibre at the end of the probe head. The distance between the tip of the excitation fibre and the tip of the collection fibre may be in the range 3 to 10 mm. In this case, the collection fibre 14 is shown in contact with a sample 17. The excitation fibre 12 is not in contact

with the sample 17, but instead is spaced apart from the sample 17.

[0037] Figure 4 (b) shows a probe head having a central excitation fibre surrounded by five collection fibres. Each of the five collection fibres has the same length, and each is longer than the central excitation fibre. In this case, the end of the probe has a U-shaped lateral profile. The distance between the tip of the excitation fibre and the tips of the collection fibres may be in the range 3 to10 mm. In this case, the collection fibres 14 are in contact with a sample 17. The excitation fibre 12 is not in contact with the sample 17, but instead is spaced apart from the sample 17.

[0038] The probe head 18 may also contain optical components in order to suit specific applications. For example, the probe head may comprise micro-lenses such as a grin lens assembly, a spherical lens, a ball lens or waveguides, in order to achieve optical focussing or divergence or to enhance the collection efficiency of the probe.

[0039] The probe head 18 may be terminated with a glass window to make the probe a contact probe. However, the optical components of the probe head must not contain any metallic substance even if non-ferromagnetic, as this would create artefact in the magnetic resonance images. In addition, to prevent unwanted RF heating, the length of these components should be less than a critical value calculated as a function of the radio frequency (RF) signal produced during MR image acquisition. The critical length for RF heating is calculated as half the wavelength of the RF signal in tissue. In the case of adipose tissue the RF signal has a wavelength of 26 cm, leading to a critical length for the optical components of 13 cm.

[0040] Figures 5 and 6 show two different probe heads modified to operate as contact probes. In Figure 5, the probe head is terminated with an optical window 20 that can be put in direct contact with a sample 17. In Figure 6, the probe head is terminated with a GRIN lens 21. The lens can be put in direct contact with the sample 17 and can also be used to enhance the collection efficiency of the probe.

[0041] Figure 7 shows a probe head, in which the respective ends of each of the excitation fibre 12 and collection fibre 14 are terminated with a pair of microlenses 22a and 22b. Figure 8 shows a probe head terminated with a single microlens 23 that covers the tips of the excitation and collection fibres. In both Figures 7 and 8, the microlenses may be spherical lenses or ball lenses selected to suit specific applications.

[0042] In all cases, the probe head 18 of the disposable optical probe 10 preferably has a diameter less than 2 mm. This allows the probe to be inserted into a surgical device 59 such as biopsy needle or a catheter. The collection and emission fibres may be separated by typically less than 1mm. For example, the fibres may be separated by a gap of less than 1mm.

[0043] Figure 9 shows an optical system 30 implemented in an MRI room 56 where an MRI scanner 58 generates a magnetic field. The optical system 30 comprises a laser 34 and a spectrometer 38 both located inside a control room 35 that is electromagnetically shielded from the MRI room 56, as well as a non-magnetic optical extension 32 and a non-magnetic disposable optical probe 10, both located inside the MRI room 56. Two Faraday cage ports 60a and 60b are provided between the control room 35 and the MRI room 56. The non-magnetic disposable optical 10 probe may be any of the probes described above. The non-magnetic optical extension comprises first and second optical fibre pigtails 42 and 50 and a filtering unit 36.

[0044] The filtering unit 36 has an excitation filtering/coupling module arranged between input port 41 and output port 43 and a collection filtering /coupling module arranged between input port 49 and output port 51. Within the housing, the excitation filtering/coupling module and output the collection filtering /coupling module are optically isolated from each other. The excitation filtering/coupling module comprises a pair of lenses 44a and 44b for collimation and refocusing and an excitation filter 46, for example a laser line filter, between the two lenses 44a and 44b. The collection filtering/coupling module has a pair of lenses 52a and 52b for collimation and refocusing and a collection filter 54 for example an edge filter between the two lenses 52a and 52b.

[0045] The first fibre pigtail 42 has an optical connector 40 at a first end and a length of exposed fibre at a second end. The first fibre pigtail is connected at the second end to the laser 34 via Faraday cage port 60a and at the first end to the filtering unit 36 via input port 41 by connector 40.The second fibre pigtail 50 has an optical connector 48 at a first end and a length of exposed fibre at a second end. The second fibre pigtail 50 is connected at the second end to the spectrometer 38 via Faraday cage port 60b and at the first end to the filtering unit 36 via output port 51 by connector 48. Alternatively, the first and second fibre pigtails may be directly secured to the filtering unit 36, i.e. without the use of connector/port assembly. In this case, each fibre may be secured permanently to the filtering unit 36.

[0046] The excitation fibre 12 of the non-magnetic disposable optical probe 10 is connected to the filtering unit 36 via output port 43 by connector 15b. The collection fibre/bundle 14 of the optical probe 10 is connected to the filtering unit 36 via input port 49 by connector 15a.

[0047] The length of the first and second fibre pigtails 42, 50 is chosen to be sufficiently long to bring the optical probe in the proximity of the MRI scanner 58. The first fibre pigtail 42 is less than 5 m long and has a 200 μm diameter. The second fibre pigtail 50 is less than 5 m long and has a 500 μm diameter. All the components of the optical system 30, such as lens mounts, fibre adaptors and cage systems are made of paramagnetic materials, although diamagnetic materials or any non-magnetic materials could equally be used.

[0048] The optical system 30 can be used to capture

a Raman signal from patient tissue. For example, the system can be used to capture a Raman signal from a biopsy sample 60 extracted during interventional MRI. During such intervention, the patient is subjected to a magnetic field strength in the region of 1.5 to 3 Tesla. A biopsy needle 59 is introduced inside the patient's body 57. The needle 59 is guided toward an area that requires examination by following the magnetic resonance images obtained by the MRI scanner 58. The optical probe 10 is inserted into the biopsy needle 59. Upon activation of the biopsy needle 59 a tissue sample enters the needle's reservoir and comes into contact with the probe head 18.

[0049] Once the sample is in contact with the probe head, the laser 34 emits a beam at an excitation wavelength suitable for Raman spectroscopy measurement. The excitation beam propagates through the first pigtail fibre 42 and is directed onto the excitation filtering/coupling module of the filtering unit 36, where the beam is collimated, filtered by the filter 46 to remove background fluorescence and focused onto the excitation fibre 12. The excitation fibre 12 delivers the excitation beam to the apex of the probe head 18 and into the sample 60, causing Raman scattering inside the sample 60. The probe head 18 then collects the back-scattered photons (which include Raman scattered photons) from the sample 60 via the collection fibre 14. The collected light is collimated, filtered by the edge filter 54 to remove out Rayleigh scattered photons and focused onto the second pig tail 50 by the collection filtering/coupling module of the filtering unit 36. The collected light is directed to the Raman spectrometer 38 where a Raman spectrum of the sample is obtained and analysed. The Raman signal can reveal the presence of cancerous tissues.

[0050] Alternatively, rather than capturing a Raman signal from a biopsy sample, the probe head could be inserted into a catheter/endoscope and brought into contact with internal tissues. In this case, the tissue is analysed locally by Raman spectroscopy.

[0051] When using a fibre based probe for an interventional procedure, it is important to keep the probe head 18 sterile. Disposable probes have to be used, unless it is possible to sterilize the whole probe after each procedure. The use of micro-optic filtering components makes the cost of commercially available fibre Raman probes too expensive to be disposable. However, in the present invention, since there are no filtering elements at the tip of the fibre, the probe 10 is disposable.

[0052] The collection efficiency of the probe was tested on various samples. Figure 10a shows a raw Raman spectrum acquired from a paracetamol tablet and Figure 10b shows a raw Raman spectrum acquired from bovine adipose tissue. The measurements were obtained with 1s acquisition time and with 200 mW excitation power and an excitation wavelength at 785 nm. It can be observed from both samples that the major Raman peaks are visible in the spectra. The obtained signal was benchmarked with a commercial fibre Raman probe with fibre pigtail length 5m and the signal to background ratio was found comparable.

[0053] The fibre Raman probe described above can be used during MRI guided interventional procedures such as needle biopsy or angioplasty. The probe is adapted to be compatible with MR environment. However, the length of the probe and the disposable probe head makes the design compatible for non-MR surgical environments.

[0054] Figure 11 shows a magnetic resonance (MR) compatible optical biopsy needle 70. The needle has a tube 72 extending between a first end and a second end and forming a bore 74. Inside the bore 74 is a disposable non-magnetic optical probe 10. The tube 72 is open at the first end and terminated at the second end by a tip 76 for cutting tissue. A window 78 is located on the tube wall at the second end. A micro-prism 80 is fixed inside the bore 74 at a location lying above the tip 76 and positioned such that light emanating from the probe 10 is directed towards the optical window 78 by the prism 80. A transparent heat shrinkable sleeve 82 sits at the second end of the needle 70 around the window 78 and is used to avoid contamination of the optical components during guidance of the needle through tissue. The non-magnetic optical probe 10 is positioned in such a way that the optimal working distance of the probe matches the distance between the tip of the probe 10 and the surface of the protective sheath 82. In this configuration the biopsy needle can operate in contact mode. All of the components of the optical biopsy needle 70 are non-magnetic. Figure 12 shows a photograph of a biopsy needle 70 next to a one pound coin.

[0055] A skilled person will appreciate that variations of the disclosed arrangements are possible without departing from the invention. For example the optical probe and optical system described above are not limited to Raman spectroscopy applications and could be modified to accommodate other type of optical spectroscopy techniques, such as nonlinear spectroscopy, fluorescence spectroscopy etc. Also, the disposable non-magnetic optical probe may be non-metallic, as well as non-magnetic. Accordingly, the above description of the specific examples and embodiments of the invention is made by way of example only and not for the purposes of limitation. It will be clear to the skilled person that minor modifications may be made without significant changes to the operation described but that the invention is defined by the independent claims.

Claims

1. An optical apparatus (10, 32) comprising a disposable non-magnetic optical fibre probe (10) for coupling light into a sample and receiving light from the sample for performing Raman spectroscopy, and a non-magnetic optical extension (32) releasably connected to the disposable non-magnetic optical probe

(10) for transmitting light into the disposable non-magnetic optical probe (10) and receiving light from the disposable non-magnetic optical probe (10), wherein the non-magnetic optical extension (32) comprises:

a first optical extension fibre (42) for transmitting light into the disposable non-magnetic optical probe (10);
a second optical extension fibre (50) for receiving light from the disposable non-magnetic optical probe (10);
an excitation filter (46) for filtering light from the first optical extension fibre (42); and
a collection filter (54) for filtering light into the second optical extension fibre (50).

2. An optical apparatus (10, 32) as claimed in claim 1 wherein the disposable non-magnetic optical fibre probe (10) is sterile and/or wherein the disposable non-magnetic optical probe (10) is adapted to be fitted in a non-magnetic biopsy needle (70).

3. An optical apparatus (10, 32) as claimed in claim 1 or claim 2 wherein the disposable non-magnetic optical probe (10) comprises a first optical fibre (12) for coupling light into the sample and at least one second optical fibre (14) for receiving light from the sample, the first and second fibres (12, 14) being connected at one end to form a probe head (18), a first optical connector (15b) at another end of the first optical fibre (12), and a second optical connector (15a) at another end of the second optical fibre (14), wherein the first and second connectors (15b, 15a) are connectable to the non-magnetic optical extension (32).

4. An optical apparatus (10, 32) as claimed in claim 3, wherein the first optical fibre (12) has a length less than a critical length so as to limit fluorescence generation upon optical excitation, optionally wherein the critical length is less than 150 cm, preferably less than 100 cm.

5. An optical apparatus (10, 32) as claimed in claim 3 or claim 4 wherein the probe head (18) has a diameter less than or equal to 2 mm.

6. An optical apparatus (10, 32) as claimed in any of claims 3 to 5 wherein a tip of the first fibre (12) is substantially aligned with a tip of the second fibre (14) or offset relative to a tip of the second fibre (14).

7. An optical apparatus (10, 32) as claimed in any of claims 3 to 6 wherein the probe head (18) comprises at least one optical component (20, 21, 22a, 22b, 23).

8. An optical apparatus (10, 32) as claimed in any preceding claim wherein the non-magnetic optical extension (32) comprises a first optical coupler (44a, 44b) for coupling light from the first optical extension fibre (42) into the disposable non-magnetic optical fibre (10) and a second optical coupler (52a, 52b) for coupling light from the disposable non-magnetic optical fibre (10) into the second optical extension fibre (50).

9. An optical apparatus (10, 32) as claimed in any preceding claim, wherein the non-magnetic optical extension (32) comprises a housing and the first filter (46) and the second filter (54) are arranged in the housing.

10. An optical apparatus (10, 32) as claimed in claim 9 when dependent on claim 8, wherein the first optical coupler (44a, 44b) and the second optical coupler (52a, 52b) are in the housing.

11. An optical apparatus (10, 32) as claimed in claim 9 or claim 10 wherein the first filter (46) and/or the first optical coupler (44a, 44b) are optically isolated from the second filter (54) and/or the second optical coupler (52a, 52b).

12. An optical apparatus (10, 32) as claimed in any of the preceding claims, wherein the optical apparatus has a total length greater than a critical length, for example greater than 3 metres, preferably greater than 4 metres, and optionally greater than 5 metres.

13. An optical apparatus (10, 32) as claimed in any of the preceding claims, wherein the disposable non-magnetic optical probe (10) is filterless.

14. A system (30) for performing optical spectroscopy comprising an imaging medical device (58) having a patient area, and an optical apparatus (10, 32) as claimed in any of claims 1 to 13 connected to a light source (34) and a detector (38), preferably a Raman spectrometer, wherein the medical device (58), preferably an MRI scanner and the optical apparatus (10, 32) are located in a first room or area (56) and the light source (34) and detector (38) are located in a second room or area (35) electromagnetically shielded from the first room or area (56).

Patentansprüche

1. Optische Vorrichtung (10, 32), die eine nicht-magnetische Einweg-Lichtleitfasersonde (10) zum Koppeln von Licht in eine Probe und Empfangen von Licht aus der Probe zum Durchführen von Raman-Spektroskopie und eine nicht-magnetische optische Verlängerung (32), die lösbar mit der nicht-magnetischen optischen Einwegsonde (10) verbunden ist, zum Weiterleiten von Licht in die nicht-magnetische

optische Einwegsonde (10) und Empfangen von Licht aus der nicht-magnetischen optischen Einwegsonde (10) umfasst, wobei die nicht-magnetische optische Verlängerung (32) Folgendes umfasst:

eine erste Verlängerungslichtleitfaser (42) zum Weiterleiten von Licht in die nicht-magnetische optische Einwegsonde (10),
eine zweite Verlängerungslichtleitfaser (50) zum Empfangen von Licht aus der nicht-magnetischen optischen Einwegsonde (10),
einen Anregungsfilter (46) zum Filtern von Licht aus der ersten Verlängerungslichtleitfaser(42) und
einen Sammelfilter (54) zum Filtern von Licht in die zweite Verlängerungslichtleitfaser (50).

2. Optische Vorrichtung (10, 32) nach Anspruch 1, wobei die nicht-magnetische Einweg-Lichtleitfasersonde (10) steril ist und/oder wobei die nicht-magnetische optische Einwegsonde (10) dafür angepasst ist, in einer nicht-magnetischen Biopsienadel (70) angebracht zu werden.

3. Optische Vorrichtung (10, 32) nach Anspruch 1 oder Anspruch 2, wobei die nicht-magnetische optische Einwegsonde (10) eine erste Lichtleitfaser (12) zum Koppeln von Licht in die Probe und wenigstens eine zweite Lichtleitfaser (14) zum Empfangen von Licht von der Probe, wobei die erste und die zweite Faser (12, 14) an einem Ende verbunden sind, um einen Sondenkopf (18) zu bilden, einen ersten Verbinder (15b) an einem anderen Ende der ersten Lichtleitfaser (12) und einen zweiten Verbinder (15a) an einem anderen Ende der zweiten Lichtleitfaser (14) umfasst, wobei der erste und der zweite Verbinder (15b, 15a) mit der nicht-magnetischen optischen Verlängerung (32) verbunden werden können.

4. Optische Vorrichtung (10, 32) nach Anspruch 3, wobei die erste Lichtleitfaser (12) eine Länge aufweist, die geringer ist als eine kritische Länge, um so eine Fluoreszenzerzeugung auf optische Anregung hin zu begrenzen, wahlweise wobei die kritische Länge geringer als 150 cm, vorzugsweise geringer als 100 cm, ist.

5. Optische Vorrichtung (10, 32) nach Anspruch 3 oder Anspruch 4, wobei der Sondenkopf (18) einen Durchmesser, kleiner als oder gleich 2 mm, aufweist.

6. Optische Vorrichtung (10, 32) nach einem der Ansprüche 3 bis 5, wobei eine Spitze der ersten Faser (12) im Wesentlichen mit einer Spitze der zweiten Faser (14) ausgerichtet oder im Verhältnis zu einer Spitze der zweiten Faser (14) versetzt ist.

7. Optische Vorrichtung (10, 32) nach einem der Ansprüche 3 bis 6, wobei der Sondenkopf (18) wenigstens ein optisches Bauelement (20, 21, 22a, 22b, 23) umfasst.

8. Optische Vorrichtung (10, 32) nach einem der vorhergehenden Ansprüche, wobei die nicht-magnetische optische Verlängerung (32) einen ersten optischen Koppler (44a, 44b) zum Koppeln von Licht aus der ersten Verlängerungslichtleitfaser (42) in die nicht-magnetischen Einweg-Lichtleitfaser (10) und einen zweiten optischen Koppler (52a, 52b) zum Koppeln von Licht aus der nicht-magnetischen Einweg-Lichtleitfaser (10) in die zweite Verlängerungslichtleitfaser (50) umfasst.

9. Optische Vorrichtung (10, 32) nach einem der vorhergehenden Ansprüche, wobei die nicht-magnetische optische Verlängerung (32) ein Gehäuse umfasst und der erste Filter (46) und der zweite Filter (54) in dem Gehäuse angeordnet sind.

10. Optische Vorrichtung (10, 32) nach Anspruch 9, wenn abhängig von Anspruch 8, wobei sich der erste optische Koppler (44a, 44b) und der zweite optische Koppler (52a, 52b) in dem Gehäuse befinden.

11. Optische Vorrichtung (10, 32) nach Anspruch 9 oder Anspruch 10, wobei der erste Filter (46) und/oder der erste optische Koppler (44a, 44b) optisch von dem zweiten Filter (54) und/oder dem zweiten optischen Koppler (52a, 52b) isoliert sind.

12. Optische Vorrichtung (10, 32) nach einem der vorhergehenden Ansprüche, wobei die optische Vorrichtung eine Gesamtlänge aufweist, die größer ist als eine kritische Länge, zum Beispiel größer als 3 Meter, vorzugsweise größer als 4 Meter und wahlweise größer als 5 Meter.

13. Optische Vorrichtung (10, 32) nach einem der vorhergehenden Ansprüche, wobei die nicht-magnetische optische Einwegsonde (10) filterlos ist.

14. System zum Durchführen optischer Spektroskopie, die eine bildgebende medizinische Vorrichtung (58) mit einem Patientenbereich und eine optische Vorrichtung (10, 32) nach einem der Ansprüche 1 bis 13, die mit einer Lichtquelle (34) und einem Detektor (38), vorzugsweise einem Raman-Spektrometer, verbunden ist, umfasst, wobei die medizinische Vorrichtung (58), vorzugsweise ein Kernspintomograph, und die optische Vorrichtung (10, 32) in einem ersten Raum oder Bereich (56) angeordnet sind und die Lichtquelle (34) und der Detektor (38) in einem zweiten Raum oder Bereich (35) angeordnet sind, der elektromagnetisch von dem ersten Raum oder Bereich (56) abgeschirmt ist.

Revendications

1. Appareil optique (10, 32), comprenant une sonde à fibre optique non magnétique à usage unique (10) pour coupler la lumière dans un échantillon et recevoir la lumière de l'échantillon afin d'effectuer une spectroscopie Raman, et une extension optique non magnétique (32) connectée de manière amovible à la sonde optique non magnétique à usage unique (10) pour transmettre la lumière dans la sonde optique non magnétique à usage unique (10) et recevoir la lumière de la sonde optique non magnétique à usage unique (10), dans lequel l'extension optique non magnétique (32) comprend :

   une première fibre d'extension optique (42) pour transmettre la lumière dans la sonde optique non magnétique à usage unique (10) ;
   une deuxième fibre d'extension optique (50) pour recevoir la lumière de la sonde optique non magnétique à usage unique (10) ;
   un filtre d'excitation (46) pour filtrer la lumière provenant de la première fibre d'extension optique (42) ; et
   un filtre de collecte (54) pour filtrer la lumière dans la deuxième fibre d'extension optique (50).

2. Appareil optique (10, 32) selon la revendication 1, dans lequel la sonde optique non magnétique à usage unique (10) est stérile et/ou dans lequel la sonde optique non magnétique à usage unique (10) est adaptée pour être ajustée dans une aiguille de biopsie non magnétique (70).

3. Appareil optique (10, 32) selon les revendications 1 ou 2, dans lequel la sonde optique non magnétique à usage unique (10) comprend une première fibre optique (12) pour coupler la lumière dans l'échantillon et au moins une deuxième fibre optique (14) pour recevoir la lumière de l'échantillon, les première et deuxième fibres (12, 14) étant connectées au niveau d'une extrémité pour former une tête de sonde (18), un premier connecteur optique (15b) au niveau d'une autre extrémité de la première fibre optique (12), et un deuxième connecteur optique (15a) au niveau d'une autre extrémité de la deuxième fibre optique (14), les premier et deuxième connecteurs (15b, 15a) pouvant être connectés à l'extension optique non magnétique (32).

4. Appareil optique (10, 32) selon la revendication 3, dans lequel la première fibre optique (12) a une longueur inférieure à une longueur critique, de sorte à limiter la génération de fluorescence lors d'une excitation optique, dans lequel la longueur critique est optionnellement inférieure à 150 cm, de préférence inférieure à 100 cm.

5. Appareil (10, 32) selon les revendications 3 ou 4, dans lequel la tête de sonde (18) a un diamètre inférieur ou égal à 2 mm.

6. Appareil optique (10, 32) selon l'une quelconque des revendications 3 à 5, dans lequel une pointe de la première fibre (12) est sensiblement alignée avec une pointe de la deuxième fibre (14) ou est décalée par rapport à une pointe de la deuxième fibre (14).

7. Appareil optique (10, 32) selon l'une quelconque des revendications 3 à 6, dans lequel la tête de sonde (18) comprend au moins un composant optique (20, 21, 22a, 22b, 23).

8. Appareil optique (10, 32) selon l'une quelconque des revendications précédentes, dans lequel l'extension optique non magnétique (32) comprend un premier coupleur optique (44a, 44b) pour coupler la lumière provenant de la première fibre d'extension optique (42) dans la sonde optique non magnétique à usage unique (10), et un deuxième coupleur optique (52a, 52b) pour coupler la lumière provenant de la sonde optique non magnétique à usage unique (10) dans la deuxième fibre d'extension optique (50).

9. Appareil optique (10, 32) selon l'une quelconque des revendications précédentes, dans lequel l'extension optique non magnétique (32) comprend un boitier, le premier filtre (46) et la deuxième filtre (54) étant agencés dans le boîtier.

10. Appareil optique (10, 32) selon la revendication 9, dépendant de la revendication 8, dans lequel le premier coupleur optique (44a, 44b) et le deuxième coupleur optique (52a, 52b) sont agencés dans le boîtier.

11. Appareil optique (10, 32) selon les revendications 9 ou 10, dans lequel le premier filtre (46) et/ou le premier coupleur optique (44a, 44b) sont optiquement isolés du deuxième filtre (54) et/ou du deuxième coupleur optique (52a, 52b).

12. Appareil optique (10, 32) selon l'une quelconque des revendications précédentes, dans lequel l'appareil optique a une longueur totale supérieure à une longueur critique, par exemple supérieure à 3 mètres, de préférence supérieure à 4 mètres, et optionnellement supérieure à 5 mètres.

13. Appareil optique (10, 32) selon l'une quelconque des revendications précédentes, dans lequel la sonde optique non magnétique à usage unique (10) ne comporte pas de filtre.

14. Système (30) pour effectuer une spectroscopie optique, comprenant un dispositif d'imagerie médicale

(58) comportant une zone patient, et un appareil optique (10, 32) selon l'une quelconque des revendications 1 à 13 connecté à une source de lumière (34), et un détecteur (38), de préférence un spectromètre Raman, dans lequel le dispositif médical (58), de préférence un scanner IRM, et l'appareil optique (10, 32) sont logés dans une première pièce ou zone (56), la source de lumière (34) et le détecteur (38) étant logés dans une deuxième pièce ou zone (35) à blindage électromagnétique par rapport à la première pièce ou zone (56).

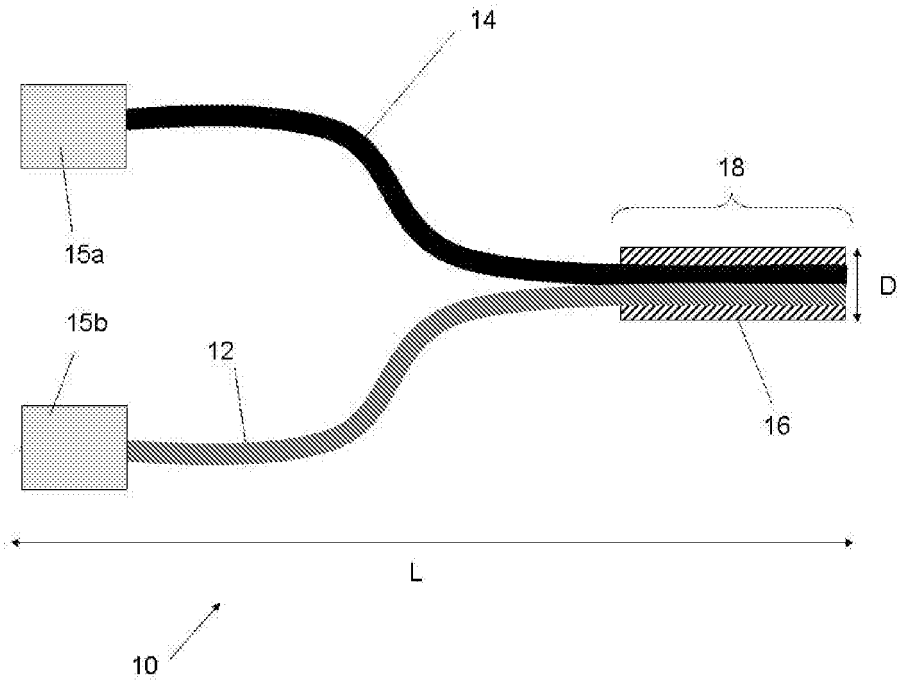


FIGURE 1

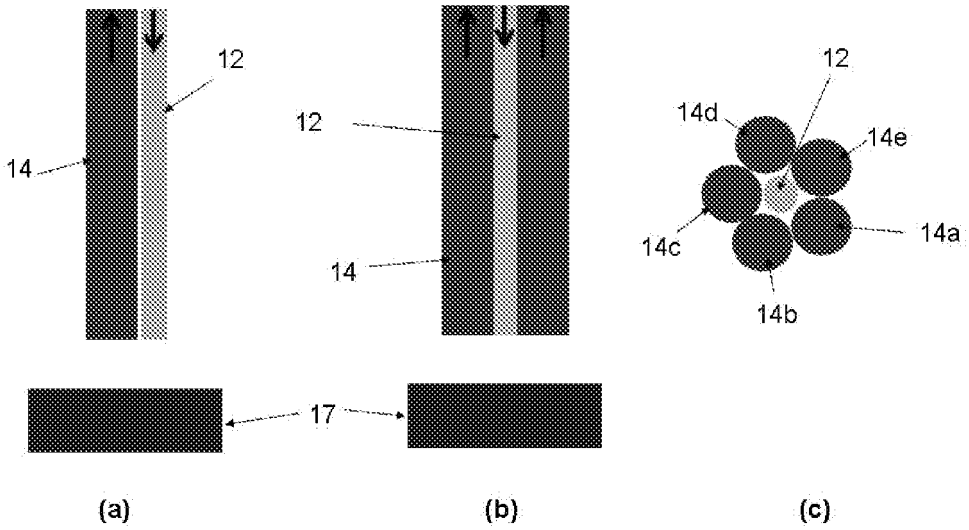


FIGURE 2

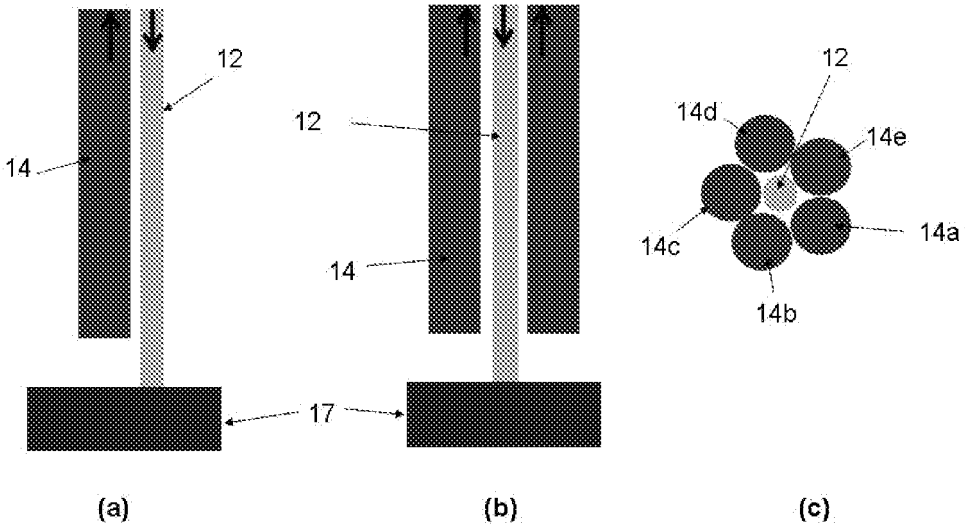


FIGURE 3

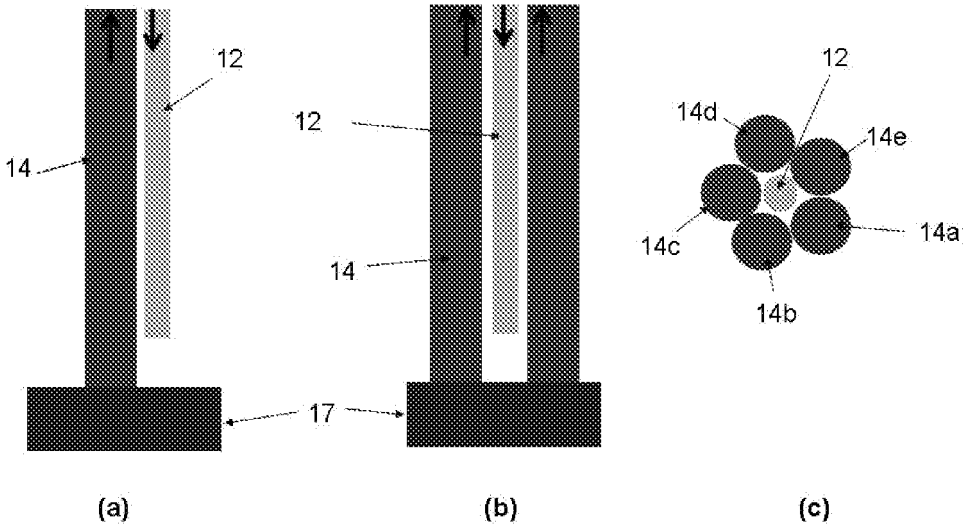
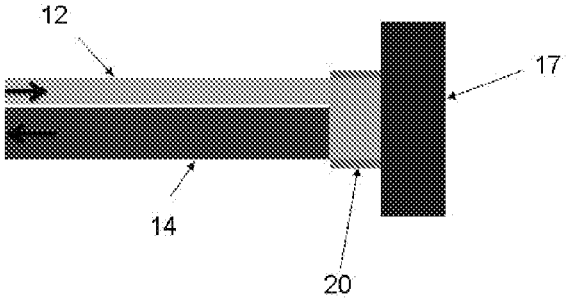


FIGURE 4



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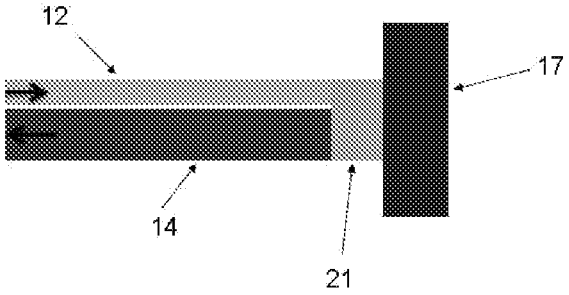


FIGURE 6

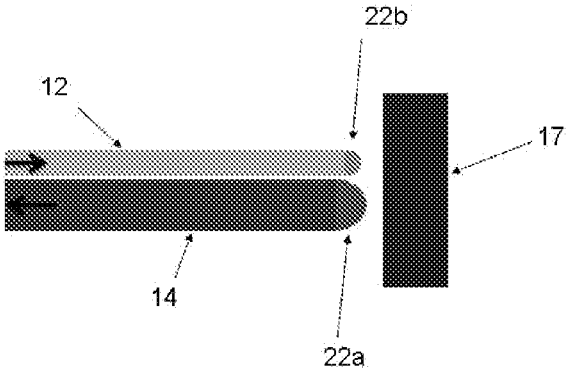


FIGURE 7

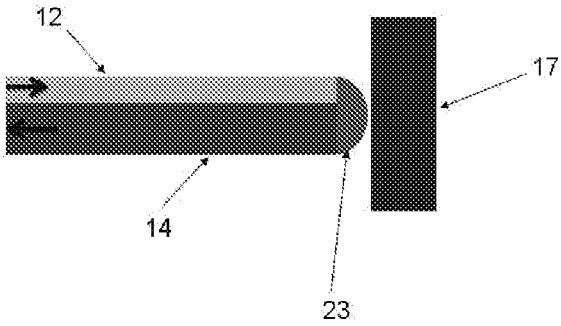
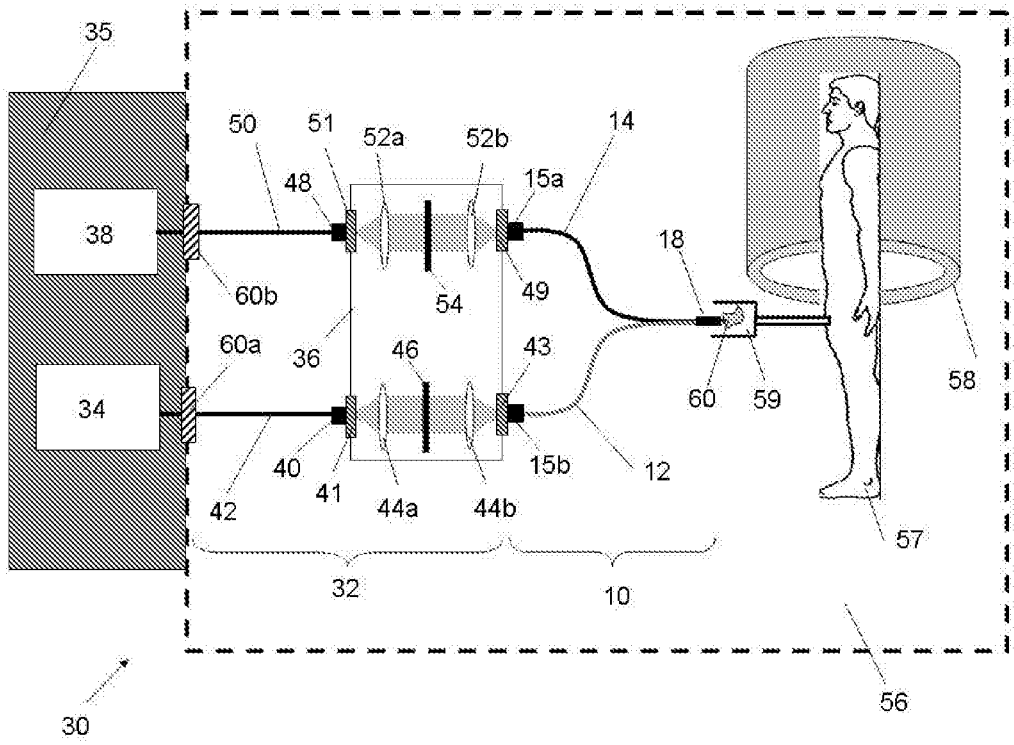


FIGURE 8



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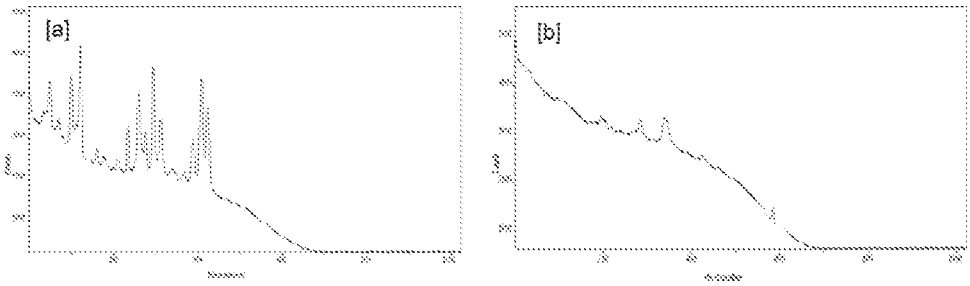

FIGURE 10

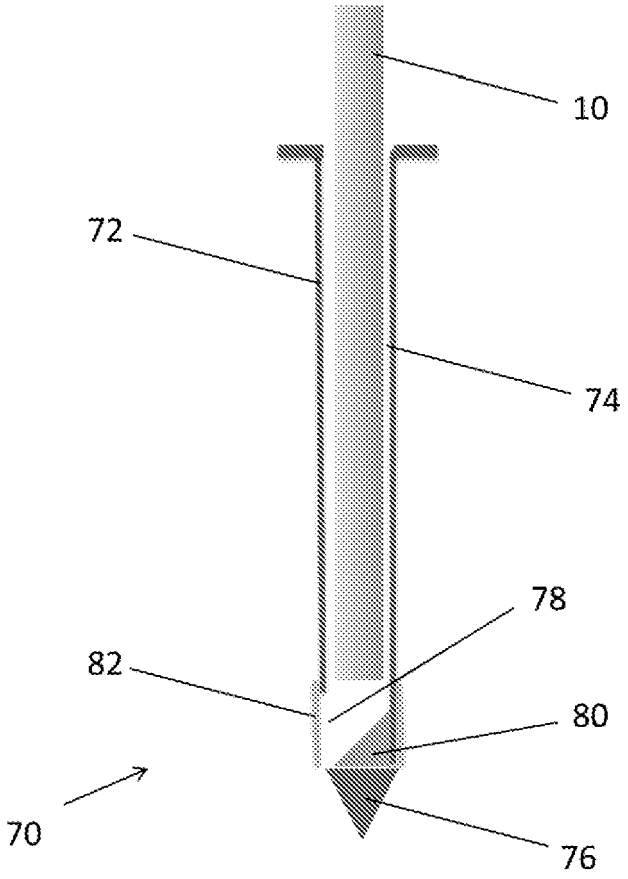

FIGURE 11

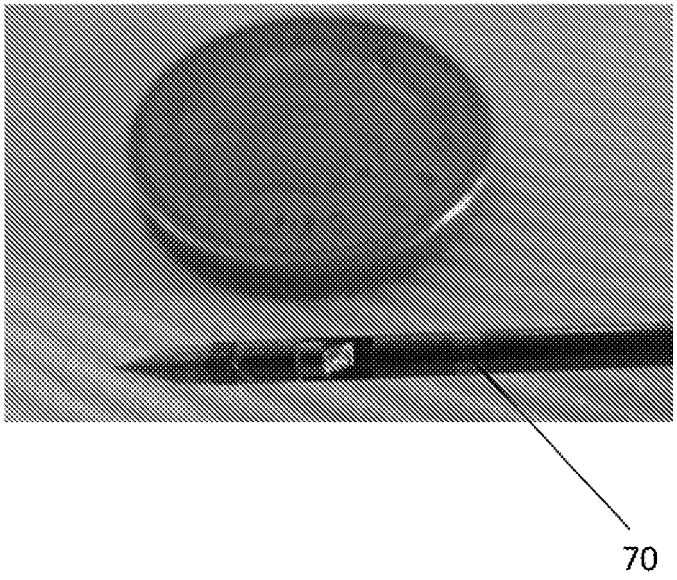

FIGURE 12

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2010122443 A **[0006]**
- WO 2013001394 A **[0007]**

专利名称(译)	用于医学成像仪的光学设备		
公开(公告)号	EP2948041A1	公开(公告)日	2015-12-02
申请号	EP2014700791	申请日	2014-01-20
[标]申请(专利权)人(译)	圣安德鲁斯大学		
申请(专利权)人(译)	翰林苑圣安德鲁斯大学		
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IPC分类号	A61B5/00 A61B5/055 A61B10/02		
CPC分类号	A61B5/0035 A61B5/0075 A61B5/055 A61B10/0275 A61B10/04 A61B2010/045 A61B2562/0233 A61B2562/164 A61B2562/227 A61B1/07 A61B5/0084 A61B5/6848 A61B5/6852		
优先权	2013001280 2013-01-24 GB		
其他公开文献	EP2948041B1		
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摘要(译)

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