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(54) **Thermal conductivity probes and methods of making the same**

Wärmeleitfähigkeitssonden und Herstellungsverfahren dafür

Sondes à conductivité thermique et leur procédé de fabrication

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Description

BACKGROUND

1. Technical Field

[0001] The present disclosure relates to electrosurgical instruments, systems and methods of making the same. More particularly, the present disclosure relates to conductivity probes for sensing directional attributes of tissue and methods of making the same.

2. *Discussion of Related Art*

[0002] It has been observed that biological tissue has different thermal and/or electrical conductivities in different directions.

[0003] Thermal conductivity of biological tissues is dependent on the particular type of biological tissue and on the composition of the biological tissue. Different biological tissues exhibit different and/or unique thermal conductivity based on factors such as tissue density, vascularization, age, direction and distance to major blood vessels, etc. Additionally, different biological tissues may exhibit a different and/or unique thermal conductivity in different directions.

[0004] Electrical conductivity is not only determined by tissue type and composition, but also by other externally applied physical and chemical influences during thermal treatment, such as, for example, temperature inducement and saline pretreatment.

[0005] Knowing the thermal and/or electrical conductivity of tissue may be used by a surgeon in a number of applications, including, but not limited to, predicting the effect of thermal treatment on given tissue, identifying the location and size of internal structures, and enhancing the resolution of traditional imaging devices.

[0006] In "Proceedings of IMECE2005 2005 ASME International Mechanical Engineering Congress and Exposition November 5-11, 2005, Orlando, Florida USA" there is disposed two-electrode micro probe was fabricated using photo-lithography IC fabrication techniques. The design layout included two electrodes, sensor area, bonding pad, and different thin film layers. The starting material for the probe fabrication is a 300 μm thick biocompatible polyimide substrate. The polyimide substrate is coated with a seed layer of 300 nm thick titanium (T_1) layer deposited by evaporation. This is followed by deposition of 300 nm gold (Au) film which forms the basis for the electrodes. The metal layer is then patterned by etching into two electrodes. These two parallel electrodes are 2000μm long, 150μm wide and are separated by a gap of 300μm. Then, an insulating dielectric layer of BCB (BisbenzoCycloButene) is spun on the top and patterned to accurately define the exact exposed electrode area for the measurement and bonding pads for soldering.

SUMMARY

[0007] Accordingly, a need exists for thermal and electrical conductivity probes for sensing the directional attributes of tissue and methods of making the same.

[0008] The present invention provides a method of making a thermal conductivity probe.

[0009] The method includes providing an inert substrate, depositing a first layer on the substrate, depositing a second layer on the first layer, generating a first pattern in the first and second layers, generating a second pattern in the second layer, and depositing an insulative layer over the first and second layers. The first and second layers may be deposited using evaporation techniques. The first layer may be selected from the group consisting of titanium (Ti), titanium tungsten (TiW) and platinum (Pt). The second layer may be selected from the group consisting of gold (AU), indium (Ir) and platinum-iridium (Pt-Ir). The first layer may measure about 50 nm thick. The second layer may measure about 500 nm thick. The first and second patterns may be generated using an etching technique.

DETAILED DESCRIPTION OF THE DRAWINGS

[0010] Embodiments of the present disclosure are disclosed herein with reference to the drawings, wherein:

FIG. 1 is a schematic perspective view of a sensing system according to an embodiment of the present disclosure;

FIG. 2 is a schematic illustration of an embodiment of a micro thermal probe of the sensing system of FIG. 1;

FIG. 2A is an enlarged view of the indicated area of detail of FIG. 2, which fabrication forms an embodiment of the present invention;

FIGS. 3-9 are schematic illustrations of exemplary steps in the fabrication of the micro thermal probe of FIG. 2;

FIG. 10 is a schematic illustration of another electrical microprobe of the sensing system of FIG. 1 which is outside the scope of the present invention;

FIG. 10A is an enlarged view of the indicated area of detail of FIG. 10;

FIGS. 11-16 are schematic illustrations of exemplary steps in the fabrication of the electrical microprobe of FIG. 10;

FIG. 17 is a schematic illustration of an electrosurgical system including the sensing system of FIG. 1, shown in operative association with a target tissue;

FIG. 18 is a perspective view of a distal end of an electrical microprobe of the present disclosure;

FIG. 19 is a transverse, cross-sectional view of an electrical microprobe as taken through 19-19 of FIG. 1;

FIG. 20 is a transverse, cross-sectional view of another electrical microprobe as taken through 19-19 of FIG. 1;

FIG. 21 is a schematic illustration of a distal end of an electrical microprobe;

FIG. 22 is a schematic illustration of a distal end of an integrated electrical and thermal microprobe;

FIG. 23 is a schematic illustration of a distal end of an electrical ablation device;

FIG. 24 is a schematic illustration of a distal end of an electrosurgical device; and

FIG. 25 is a schematic illustration of a distal end of an electrosurgical device.

DETAILED DESCRIPTION OF EMBODIMENTS

[0011] The devices, systems and methods of the present disclosure provide for the sensing of directional attributes of tissue in order to help in predicting and/or planning thermal therapy procedures. In the drawings and in the description which follows, the term "proximal", as is traditional, will refer to the end of the system, or component thereof, which is closest to the operator, and the term "distal" will refer to the end of the system, or component thereof, which is more remote from the operator.

[0012] As used herein, the term "thermal treatment" is understood to include and is not limited to radio-frequency (RF) treatment, laser treatment, microwave treatment and cryoablation treatment.

1. Sensing System

[0013] With reference to FIG. 1, in accordance with an embodiment of the present disclosure, a sensing system for sensing directional attributes of tissue is generally designated as 100. System 100 includes a thermal conductivity probe 200, power supply "PS" connected to or connectable to probe 200, a multimeter "M" connected to or connectable to probe 200, and a computer "C" connected to or connectable to multimeter "M". System 100 may further include an electrical conductivity probe 300 connected to an impedance analyzer "IA", or other suitable devices. Impedance analyzer "IA" may be formed integral with multimeter "M", or may instead include a separate unit. Power supply "PS" may include any power source capable of providing constant power. For example, power supply "PS" may include a DC power source.

[0014] As seen in FIG. 1, thermal conductivity probe 200 includes a first pair of bonding pads 202 electrically connected to or electrically connectable to power supply "PS", and a second pair of bonding pads 204 electrically connected to or electrically connectable to multimeter "M". Electrical conductivity probe 300 may include a pair of bonding pads 304 electrically connected to or electrically connectable to impedance analyzer "1A".

2. Thermal Conductivity Probe

[0015] A micro thin-film thermal conductivity probe has been developed to measure thermal conductivity of biological tissues based on the principle of traditional hot-wire method. An embodiment of the design of the microprobe of the present disclosure includes a resistive line heating element on a substrate and a Resistance Temperature Detector (RTD) based temperature sensor.

[0016] With continued reference to FIG. 1 and with reference to FIGS. 2 and 2A. a more detailed discussion of thermal conductivity probe 200 is provided. Probe 200 may be in the form of a needle, probe antenna or the like or any other suitable configuration. In one embodiment, probe 200 may include an elongate body 210, in the form of a catheter, defining a sharpened or pointed distal tip 212.

[0017] Probe 200 further includes a microprobe sensor 220 suitably secured to catheter 210. Microprobe sensor 220 may be disposed at least partially within catheter 210, on an outer surface of catheter 210, imbedded in the outer surface of catheter 210 and/or according to any other suitable method.

[0018] As seen in FIGS. 2 and 2A, microprobe sensor 220 includes a line heating element 222 having a pair of resistive inner thin-film heating elements 222a, 222b, a detector element 224 having a pair of outer "resistance temperature detector" (RTD) elements 224a, 224b, and a substrate 226 for supporting heating elements 222a, 222b and RTD elements 224a, 224b.

[0019] In one embodiments line hearing element 222 has a width of approximately 100μm and a length of approximately 5000μm. Meanwhile, detector element 224 may have a width of approximately 100μm and a length of approximately 1500μm. The dimensions disclosed herein are representative, it is envisioned and within the scope of the present disclosure for the dimensions to have any suitable value, such as, for example, having lengths that are approximately 3.0 times greater than the lengths specified or having lengths that are approximately 0.2 times less than the lengths specified. It is contemplated that the lengths selected, for example, may be chosen for optimal use in a specific target tissue, e.g., liver, lung, kidney, muscle, etc.

[0020] As best seen in FIG. 2A, heating elements 222a. 222b of line heating element 222 are substantially parallel to one another and are spaced a distance "YI" from one another. Distance "Y1" may be approximately 100μm. Each heating element 222a, 222b is spaced apart from a respective RTD element 224a, 224b by a distance "Y2". Distance "Y2" maybe approximately 50μm.

[0021] Turning now to FIGS. 3-9, a representative method of manufacturing microprobe sensor 220 according to the present invention is shown and described. The steps involved in the manufacture of microprobe sensor 220 include, as seen in FIG. 3, providing a substrate 226, e.g., glass, polyimide (kapton) or other polymeric substrate that is inert. In an embodiment, substrate 226 may have a thickness approximately equal to 1.0mm. Next, as seen in FIG. 4, a first layer 228 is deposited on substrate 226 using evaporation techniques or other suitable deposition technique. First layer 228 may be fabricated from titanium (Ti) titanium tungsten (TiW), platinum (Pt) or other like materials, and may have a thickness of approximately 50nm. Next, as seen in FIG. 5, a second layer 230 is deposited on first layer 228 using evaporation techniques or other suitable deposition techniques. Second layer 230 may be fabricated from gold (Au), iridium (Ir), platinum-iridium alloy (Pt-Ir) or other like materials, and may have a thickness of approximately 500nm. The dimensions of microprobe sensor 220 provided herein are merely representative, and may be made larger or smaller depending on the application. For example, microprobe sensor 220 may be reduced in size when configured for use with infants. In one exemplary embodiment, microprobe sensor 220 may include a substrate 226 having a thickness approximately equal to 300μm to 1000μm, and in a further embodiment approximately equal to 500μm.

[0022] As seen in FIG. 6, suitable photolithography techniques or other suitable etching or removal techniques are used to generate a desired first pattern 232 in first and second layers 228, 230 by using a precision photomask (not shown). Next, as seen in FIG. 7, second layer 230 is etched, using photolithography techniques or other suitable etching or removal techniques, to create a second pattern 234 therein. In this manner, the heating elements and the RTD elements are defined.

[0023] As seen in FIG. 8, an insulating layer 236 is deposited, i.e., spun onto, overtop first and second layers 228, 230 and first and second patterns 232, 234. Insulating layer 236 may comprise a dielectric layer of benzocyclobutane (BCB), silica (SiO2), parylene, polyimide, SU8, or other like materials. Insulating layer 236 functions to protect first and second layers 228, 230 from corrosive element in tissue, such as, for example, saline. As seen in FIG. 9, areas 238 are exposed in insulating layer 236 to define bonding pads 202, 204 and expose bonding pads 202, 204 for soldering or the like. Sensor 220 may further be coated with a hydrophilic or hydrophobic layer (not shown) for increasing the biocompatibility of sensor 220.

[0024] Wires (not shown) may be welded, soldered, ball bonded, epoxied, etc. to each bonding pad 202, 204 and microprobe sensor 220 may then be placed within elongate body 210 (see FIG. 1). A waterproof epoxy may be used to hold microprobe sensor 220 in place within elongate body 210 and to protect microprobe sensor 220.

3. Method of Using Thermal Conductivity Probe

[0025] With reference to FIGS. 1-2A, a representative method of using thermal conductivity probe 200, is provided. As seen in FIG. 1, with the first pair of bonding pads 202 electrically connected to power source "PS", and with the second pair of bonding pads 204 electrically connected to multimeter "M", thermal conductivity probe 200 may be used to determine the thermal conductivity of target tissue. The transient time response of heating elements 222a, 222b is dependent on a thermal conductivity of the medium surrounding microprobe sensor 220 and the substrate underlying

microprobe sensor 220.

[0026] According to a method of the present disclosure, a 5V output, generated by power source "PS", is used to provide a constant current through heating elements 222a, 222b. A resistance change of the RTD elements 224a, 224b, due to the transient temperature elevation, is measured by multimeter "M", an impedance analyzer or the like. Computer "C" is used to monitor, record and acquire the data and/or readings generated by microprobe sensor 220.

[0027] The transient time response of the RTD elements 224a, 224b depends on the thermal conductivity of the surrounding medium and the substrate. A theoretical analysis of the transient conduction, for a configuration where the heater source is sandwiched between two materials (the substrate and the surrounding medium), shows that the composite thermal conductivity calculated from the temperature versus the logarithm of time response is simply an average of the thermal conductivity of the two materials.

[0028] The equation for the calculation is:

$$k = \frac{k_{tissue} + k_{substrate}}{2} = \frac{q''}{2\pi}\left(\frac{dT}{d\ln t}\right)^{-1}$$

k - is the calculated thermal conductivity;
k_{tissue} - is the thermal conductivity of the tested tissue;
$k_{substrate}$ - is the thermal conductivity of the sensor substrate;
q'' - is the heat flux produced by heating element;
T - is the temperature; and
t - is the time.

[0029] In use, catheter 210 is inserted into the target tissue "T" and microprobe sensor 220 is activated to determine the thermal conductivity of said target tissue. Thermal conductivity probe 200 is adapted to measure thermal conductance K_{eff} as represented by the following equation, as commonly known in the field:

$$K_{eff} = K\left\{1 + \frac{n\left[(\rho c)_b \pi r_b^2 \overline{V} \cos\gamma\right]^2}{\sigma_\Delta K^2}\right\} + q_{met}$$

where:

k_{eff} - is the "effective" tissue conductance which is measured. K_{eff} is the combination of conduction (due to intrinsic thermal conductivity) and convection (due to perfusion);
k_{tissue} - is tissue conductance in the absence of perfusion;
n - is the number of blood vessels;
p - in $(pc)_b$ is the density af blood;
c - in $(pc)_b$ is the specific heat of blood;
r_b - is vessel radius;
V - is the blood flow velocity vector within the vessel,
γ - is the relative angle between blood vessel direction and tissue temperature gradient;
σ_Δ - is a shape factor term; and
q_{mel} - is metabolic heat generation.

-S. Weinbaum and L.M. Jiji, "A new simplified equation for the effect of blood flow on local average tissue temperature," ASME J. Biomech. Eng. 107 : 131-139, 1985.

4. Electrical Conductivity Probe

[0030] With reference to FIG. 1 and with reference to FIGS. 10 and 10A, a more detailed discussion of electrical conductivity probe 300 outside the scope of the present invention is provided. Probe 300 may be in the form of a needle, probe antenna or the like or any suitable configuration. For example, probe 300 may include an elongate body 310, in the form of a catheter, defining a sharpened or pointed distal tip 312.

[0031] Probe 300 further includes a sensor 320 suitably secured to catheter 310. Sensor 320 may be disposed at least partially within catheter 310, on an outer surface of catheter 310, imbedded in the outer surface of catheter 310 and/or according to any other suitable.

[0032] As seen in FIGS. 10 and 10A. sensor 320 includes a pair of electrodes 322a. 322b defining a sensor area "SA", a pair of electrical leads 323a, 323b respectively connecting electrodes 322a, 322b to bonding pads 304, and a substrate 326 for supporting electrodes 322a, 322b, leads 323a, 323b and bonding pads 304.

[0033] In one embodiment, each electrode 322a, 322b has a width of approximately 150μm and a length of approximately 2,000μm. While the dimensions disclosed herein are representative or exemplar, it is envisioned and within the scope of the present disclosure for the dimensions to have any suitable value, such as, for example, having lengths that are approximately 3.0 times greater than the lengths specified or having lengths that are approximately 0.2 times less than the lengths specified. It is contemplated that the lengths selected, for example, may be chosen for optimal use in a specific target tissue, e.g., liver, lung, kidney, muscle, etc. As best seen in FIGS. 10 and 10A, electrodes 322a, 322b are substantially parallel to one another and are spaced a distance "Y3" from one another. Distance "Y3" may be approximately 300μm.

[0034] Turning now to FIGS. 11-16, an exemplary method of manufacturing sensor 320 outside the scope of the present invention is shown and described. The steps involved in the manufacture of sensor 320 include, as seen in FIG . 11, providing a substrate. 326, e.g., a polyimide or other suitable substrate that is inert. In an embodiment, substrate 326 may have a thickness between approximately 300μm and 1,000μm, and in a further embodiment may be approximately 500μm. Next, as seen in FIG. 12, an adhesive layer 328 is deposited on substrate 326 using suitable deposition by evaporation techniques or other suitable deposition and/or evaporation techniques. Adhesive layer 328 may be fabricated from titanium (Ti) titanium tungsten (TiW), platinum (Pt) or other like materials, and may have a thickness of approximately 30nm. Next, as seen in FIG. 13, a conductive layer 330 is deposited on adhesive layer 228 using suitable deposition by evaporation techniques or other suitable deposition and/or evaporation techniques. Conductive layer 330 may be fabricated from gold (Au), iridium (Ir), platinum-iridium alloy (Pt-Ir) or other like materials, and may have a thickness of approximately 300nm. The dimensions of microprobe sensor 320 provided herein are merely representative, and may be made larger or smaller depending on the application.

[0035] As seen in FIG. 14, suitable photolithography and/or etching techniques are used to generate a desired pattern 332 defining first and second electrodes 322a, 322b. Next, as seen in FIG. 15, an insulating layer 336 is deposited, e.g., spun onto, overtop conductive layer 330 and pattern 332. Insulating layer 336 may comprise a dielectric layer of benzocyclobutane (BCB), silica (SiO_2), parylene C or other like materials. Insulating layer 336 functions to protect conductive layer 330 from corrosive element in tissue, such as, for example, saline. As seen in FIG. 16, areas 338 are patterned into insulating layer 336 to define first and second electrodes 322a, 322b and bonding pads 304 and to expose bonding pads 304 for soldering or the like.

[0036] Wires (not shown) may be welded, soldered, ball bonded, epoxied, etc. to each bonding pad 304 and sensor 320 may then be paced within elongate body 310 (see FIG. 1). A waterproof epoxy may be used to hold sensor 320 in place within elongate body 310 and to protect sensor 320. Sensor 320 may further be coated with a hydrophilic or hydrophobic layer (not shown) for increasing the biocompatibility of sensor 320.

5. Method of Using Electrical Conductivity Probe

[0037] With reference to FIGS. 1, 10 and 10A, a representative method outside the scope of the present invention of using electrical conductivity probe 300, is provided. As seen in FIG. 1, with the pair of bonding pads 304 electrically connected to multimeter "M" or impedance analyzer, electrical conductivity probe 300 may be used to determine the electrical conductivity of target tissue prior to an electrosurgical procedure.

[0038] According to a method of the present disclosure, a 500kHz output frequency, generated by multimeter "M", is used to provide electrosurgical energy to electrodes 322a, 322b. A return pad or electrode (not shown) is employed to complete a circuit with electrodes 322a, 322b, via tissue "T". The computer "C" is used to monitor, record and acquire the data and/or readings generated by sensor 320.

[0039] Before use, the impedance values by the micro electrical probe are calibrated in different salinity levels against the standard four-electrode probe which provides a direct measure of the electrical conductivity. A calibration curve is generated that relate the impedance value given by the micro electrical probe to the electrical conductivity measured by the standard four-electrode probe at different salinity levels. The electrical conductivity can be calculated by comparing the impedance value with the calibration curve. In use, catheter 310 is inserted into the target tissue "T" and sensor 320 is activated to determine the electrical conductivity of said target tissue "T".

[0040] While each of the above embodiments illustrates a single sensor 220, 320 associated with each respective device 200, 300, in accordance with the present disclosure, devices 200, 300 may employ or include at least two or multiple sensors 220, 320 disposed around a circumference thereof. As seen in FIG. 19, each of devices 200, 300 may include a pair of sensors 220a, 320a disposed on opposed sides thereof, or as seen in FIG. 20, each of devices 200,

300 may include a sensors 220b, 320b disposed at 90° angles relative to one another.

[0041] As seen in FIG. 21, sensors 220, 320 may be disposed at different axial locations along a length of respective catheter 210, 310. As seen in FIG. 22, sensors 220, 320 may be provided on a single electrosurgical device 400. In this manner, electrosurgical device 400 will be capable of measuring and/or capturing both the values of thermal conductivity and electrical conductivity of target tissue "T".

[0042] According to an alternate embodiment of the present disclosure, as seen in FIG. 22, sensors 220, 320 may be incorporated into or otherwise associated with a thermal treatment device 500, in the form of an ablation needle, probe, antenna or the like. Thermal treatment device 500 defines an electrically exposed distal tip 502 configured and adapted to deliver therapeutic energy to target tissue, according to any suitable known method in the art. Distal tip 502 extends from an insulated shaft 504 or the like.

[0043] As seen in FIG. 23, sensors 220, 320 may be provided along and/or incorporated into distal tip 502 and/or provided along and/or incorporated into shaft 504. The particular arrangement, location and orientation of sensors 220, 320 relative to one another and relative to distal tip 502 and 504 may be selected or chosen as needed and/or desired.

[0044] As seen in FIG. 24, sensors 220, 320 may be provided along and/or incorporated into an outer tube 602 of a thermal treatment device 600. In this manner, outer tube 602 of thermal treatment device 600 may be retracted relative to shaft 604, or in the alternative, shaft 604 may be extended relative to outer tube 602, to expose an operational end 606 of thermal treatment device 600. In an alternate embodiment, as seen in FIG. 25, sensors 220, 320 may be provided along and/or incorporated into a shaft 702 of a thermal treatment device 700. In this manner, shaft 702 of thermal treatment device 700 may be extended relative to an operational outer tube 704, thereby exposing sensors 220, 320. In a further embodiment, operational outer tube 704 may be replaced with an energy delivery needle or the like for delivering therapeutic energy to surrounding tissue and thermal treatment device 700 may be extended relative to energy delivery needle 704.

[0045] While several embodiments of the disclosure have been shown in the drawings, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification be read likewise. Therefore, the above description should not be construed as limiting, but merely as exemplifications of preferred embodiments. Those skilled in the art will envision other modifications within the scope of the claims appended hereto.

Claims

1. A method of making a thermal conductivity probe (200), the method comprising the steps of:

providing an inert substrate (226);
depositing a first layer (228) on the substrate;
depositing a second layer (230) on the first layer;
etching a first pattern (232) in the first and second layers;
etching a second pattern (234) in the second layer;
depositing an insulative layer (236) over the first and second layers; and
exposing areas in the insulating layer to define bonding pads.

2. The method of claim 1, further comprising the step of depositing the first and second layers using evaporation techniques.

3. The method of claim 1, wherein the first layer is selected from the group consisting of titanium (Ti), titanium tungsten (TiW) and platinum (Pt).

4. The method of claim 1, wherein the second layer is selected from the group consisting of gold (AU), iridium (Ir) and platinum-iridium (Pt-Ir).

5. The method of claim 1, further comprising a step of providing the first layer measuring approximately 50 nm thick.

6. The method of claim 1, further comprising a step of providing the second layer measuring approximately 500 nm thick.

7. The method of claim 1, wherein the thermal conductivity probe (200) is for sensing directional attributes of tissue (T), and the probe (200) comprises:

a body (210) ; and

a sensor (220) operably coupled to the body (210), wherein the sensor (220) includes:
a line heater (222) having at least one resistive heating element (222a);
a detector (224) having at least one detector element (224a); and
the substrate (226) for supporting the line heater (222) and the detector (224), wherein the method comprises forming the at least one heating element (222a) and the at least one detector element (224a) by the etching steps.

8. The method of claim 7, wherein the body defines a catheter configured for insertion into tissue (T).

9. The method of claim 7 or 8, the sensor comprising a pair of outer detector elements (224a, 224b) that are resistance temperature detector elements (RTD).

10. The method of claim 7, 8 or 9, the sensor comprising a pair of inner heating elements (222a, 222b) that are substantially parallel.

11. The method of any one of claims 8 to 10 wherein the probe (200) further includes an array of sensors.

Patentansprüche

1. Verfahren zum Herstellen einer Wärmeleitfähigkeitssonde (200), das Verfahren die Schritte umfassend:

Bereitstellen eines inerten Substrats (226);
Anlagern einer ersten Lage (228) an dem Substrat;
Anlagern einer zweiten Lage (230) an der ersten Lage;
Ätzen einer ersten Struktur (232) in die erste und zweite Lage;
Ätzen einer zweiten Struktur (234) in die zweite Lage;
Anlagern einer isolierenden Lage (236) über der ersten und zweiten Lage; und
Freilegen von Bereichen in der isolierenden Lage, um Bondinseln zu definieren.

2. Verfahren nach Anspruch 1, ferner den Schritt eines Anlagerns der ersten und zweiten Lage unter Verwendung von Aufdampftechniken umfassend.

3. Verfahren nach Anspruch 1, bei dem die erste Lage aus der Gruppe ausgewählt wird, die aus Titan (Ti), Titan-Wolfram (TiW) und Platin (Pt) besteht.

4. Verfahren nach Anspruch 1, bei dem die zweite Lage aus der Gruppe ausgewählt wird, die aus Gold (AU), Iridium (Ir) und Platin-Iridium (Pt--Ir) besteht.

5. Verfahren nach Anspruch 1, ferner den Schritt eines Bereitstellens der ersten Lage mit einer Dicke von in etwa 50 nm umfassend:

6. Verfahren nach Anspruch 1, ferner den Schritt eines Bereitstellens der zweiten Lage mit einer Dicke von in etwa 500 nm umfassend.

7. Verfahren nach Anspruch 1, bei dem die Wärmeleitfähigkeitssonde (200) zum Erfassen von Richtungseigenschaften von Gewebe (t) ist und die Sonde (200) aufweist:

einen Körper (210); und
einen Sensor (220), der betriebsfähig mit dem Körper (210) gekoppelt ist, wobei der Sensor (220) aufweist:

eine Linienheizeinrichtung (222), die mindestens ein Widerstandsheizelement (222a) aufweist;
einen Detektor (224), der mindestens ein Detektorelement (224a) aufweist; und
das Substrat (226) zum Unterstützen der Linienheizeinrichtung (222) und des Detektors (224), wobei das Verfahren ein Ausbilden des mindestens einen Heizelements (222a) und des mindestens einen Detektorelements (224a) durch die Ätzschritte umfasst.

8. Verfahren nach Anspruch 7, bei dem der Körper einen Katheter definiert, der zum Einführen in Gewebe (T) eingerichtet ist.

9. Verfahren nach Anspruch 7 oder 8, bei dem der Sensor ein Paar äußere Detektorelemente (224a, 224b) aufweist, die Widerstandstemperaturdetektorelemente (RTD) sind.

10. Verfahren nach Anpruch 7, 8, oder 9, bei dem der Sensor ein Paar innerer Heizelemente (222a, 222b) aufweist, die im Wesentlichen parallel sind.

11. Verfahren nach einem der Ansprüche 8 bis 10, bei dem die Sonde (200) ferner einen Sensorarray aufweist.

Revendications

1. Procédé de fabrication d'une sonde à conductivité thermique (200), le procédé comprenant les étapes de :

réaliser un substrat inerte (226) ;
déposer une première couche (228) sur le substrat ;
déposer une deuxième couche (230) sur la première couche ;
graver un premier motif (232) dans les première et deuxième couches ;
graver un deuxième motif (234) dans la deuxième couche ;
déposer une couche d'isolation (236) sur les première et deuxième couches ; et
exposer des zones dans la couche d'isolation pour définir des plots de connexion.

2. Procédé selon la revendication 1, comprenant en outre l'étape consistant à déposer les première et deuxième couches en utilisant des techniques d'évaporation.

3. Procédé selon la revendication 1, dans lequel la première couche est sélectionnée dans le groupe consistant en titane (Ti), titane tungstène (TiW) et platine (Pt).

4. Procédé selon la revendication 1, dans lequel la deuxième couche est sélectionnée dans le groupe consistant en or (AU), iridium (Ir) et platine-iridium (Pt-Ir).

5. Procédé selon la revendication 1, comprenant en outre une étape consistant à réaliser la première couche pour qu'elle mesure approximativement 50 nm en épaisseur.

6. Procédé selon la revendication 1, comprenant en outre une étape consistant à réaliser la deuxième couche pour qu'elle mesure approximativement 500 nm.

7. Procédé selon la revendication 1, dans lequel la sonde à conductivité thermique (200) est destinée à détecter des attributs directionnels du tissu (T), et la sonde (200) comprend :

un corps (210) ; et
un capteur (220) fonctionnellement couplé au corps (210), où le capteur (220) comprend :

un ruban chauffant (222) comportant au moins un élément chauffant résistif (222a) ;
un détecteur (224) ayant, au moins un élément de détection (224a) ; et
le substrat (226) pour supporter le ruban chauffant (222) et le détecteur (224), où le procédé comprend la formation dudit au moins un élément chauffant (222a) et dudit au moins un élément de détection (224a) par les étapes de gravure.

8. Procédé selon la revendication 7, dans lequel le corps définit un cathéter configuré pour l'insertion dans le tissu (T).

9. Procédé selon la revendication 7 ou 8, le capteur comprenant une paire d'éléments de détection extérieures (224a, 224b) qui sont des éléments de détection de température à résistance (RTD).

10. Procédé selon la revendication 7, 8 ou 9, le capteur comprenant une paire d'éléments chauffants intérieurs (222a, 222b) qui sont sensiblement parallèles.

11. Procédé selon l'une quelconque des revendications 8 à 10, dans lequel la sonde (200) comprend en outre un ensemble de capteurs.

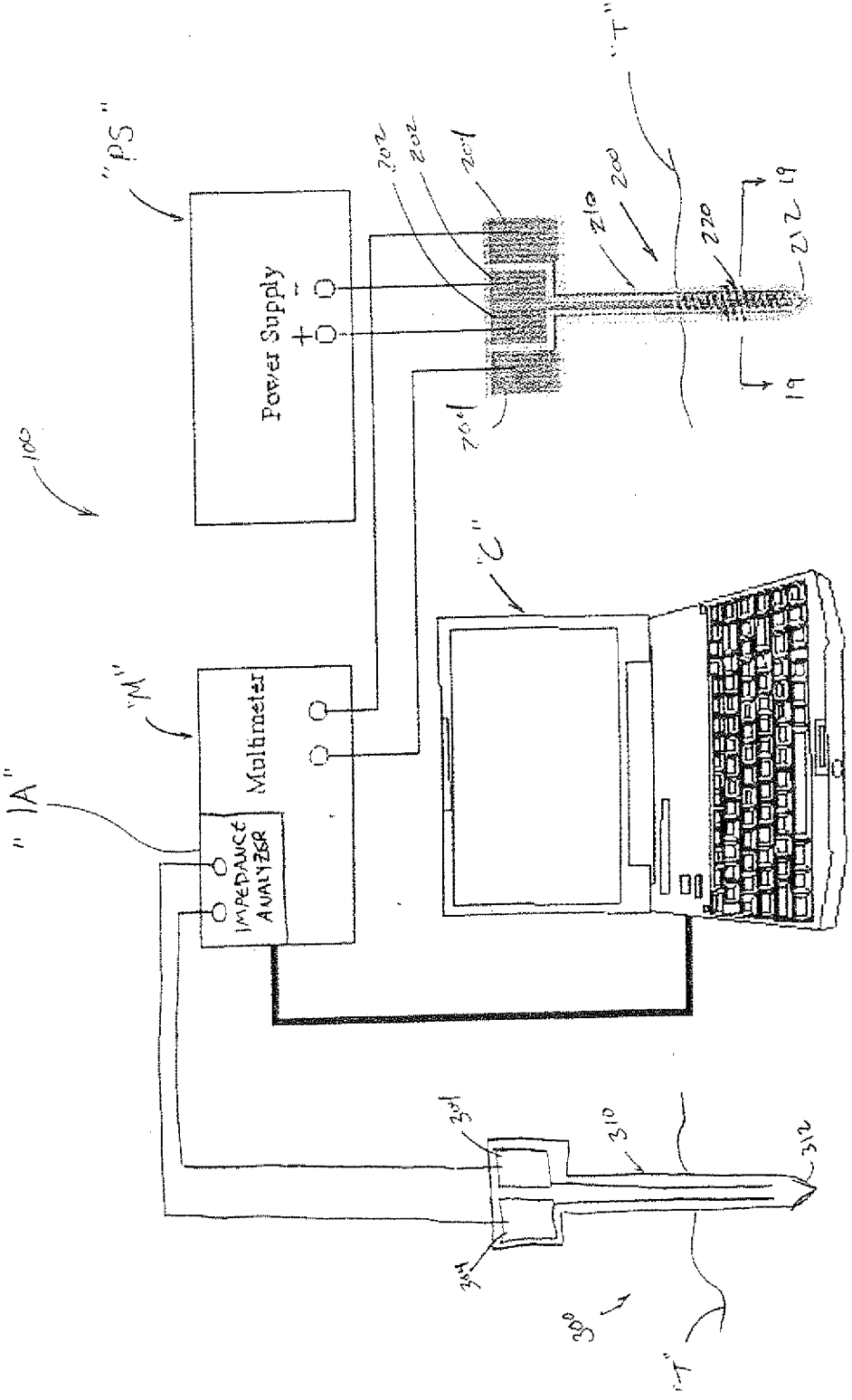
"PS"
Power Supply
+
-
202
202
201
210
200
220
212
19
19
"T"
204
100
"C"
"M"
Multimeter
"IA"
IMPEDANCE ANALYZER
301
310
312
304
30°
"T"

Fig. 1

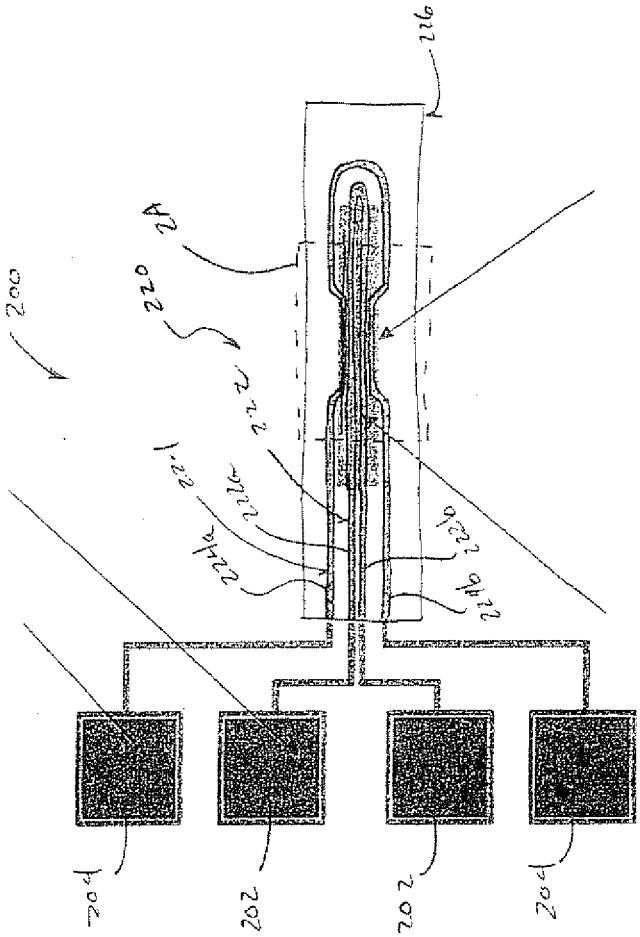

Fig. 2

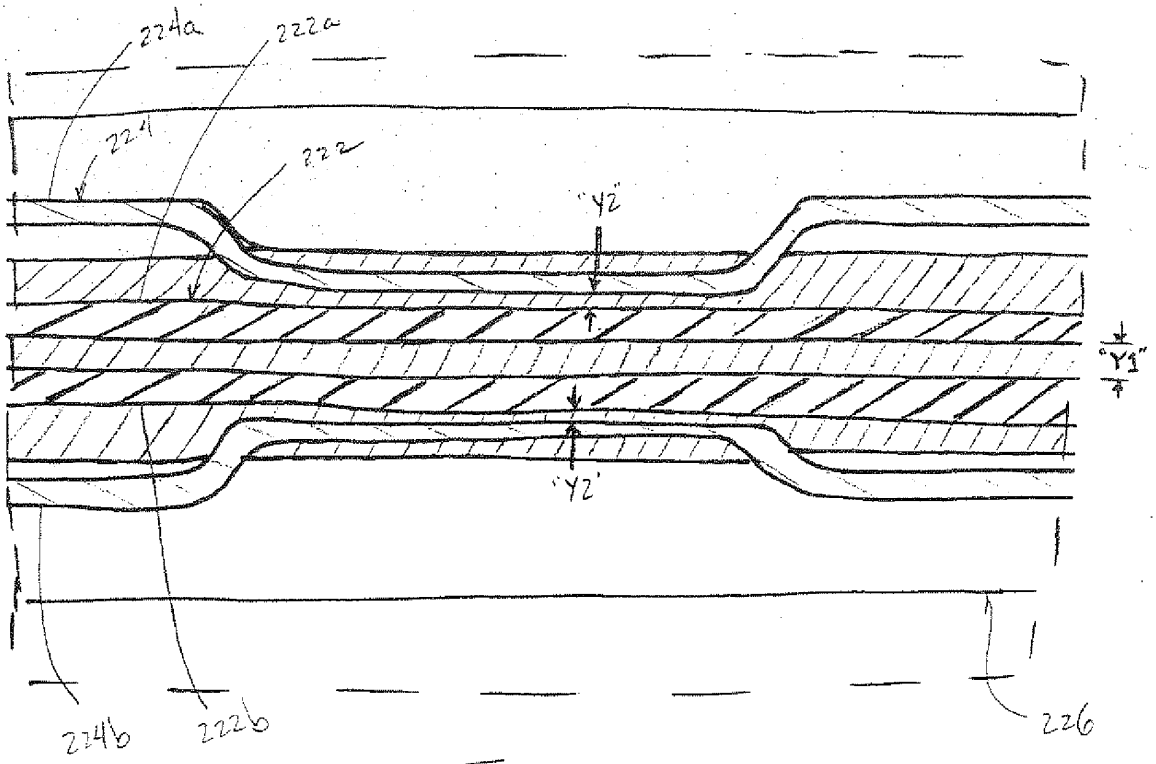

Fig. 2A

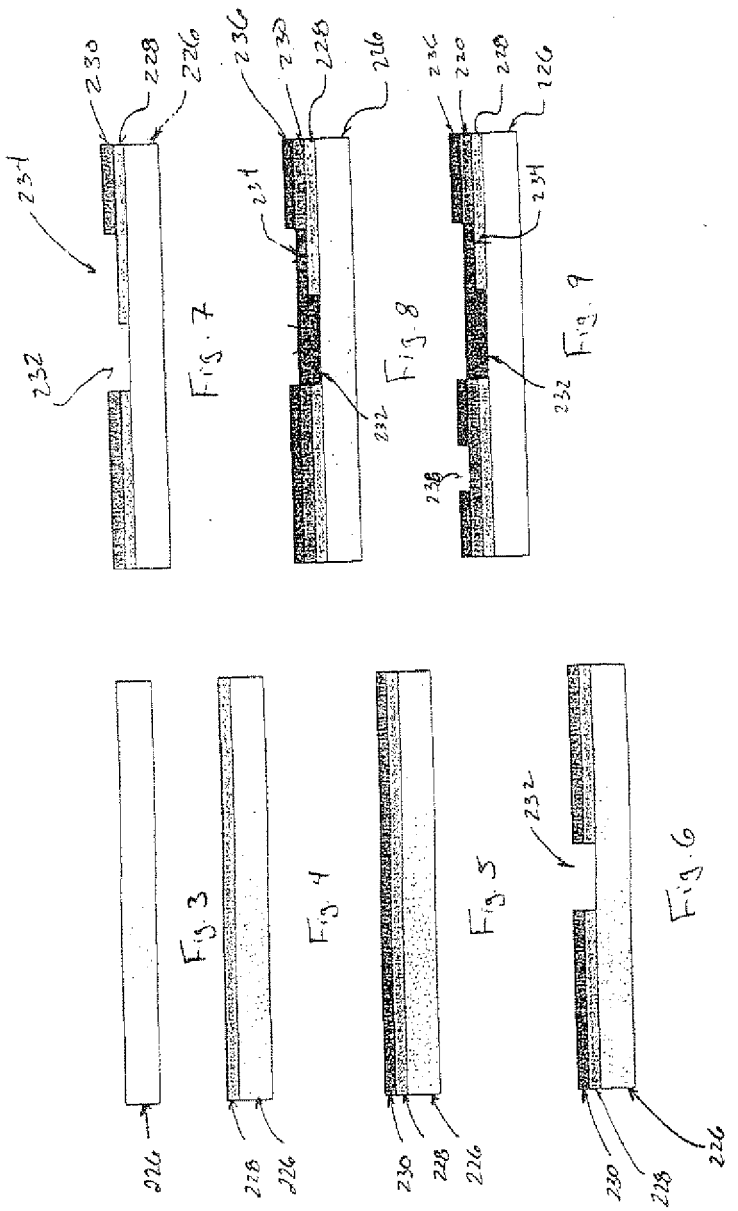

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

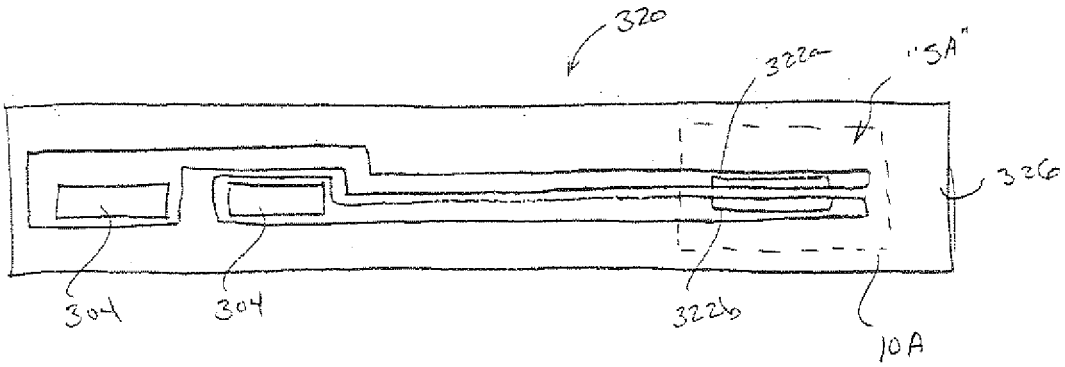

Fig. 10

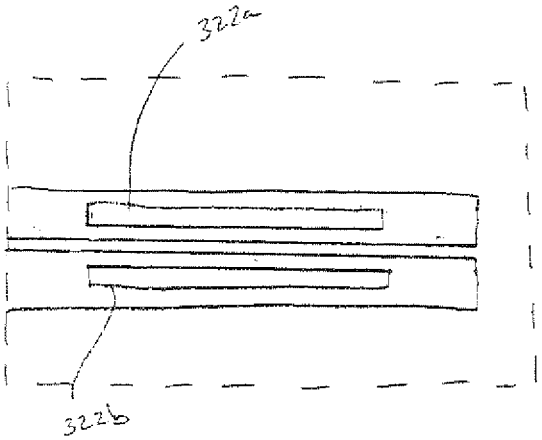

Fig. 10A

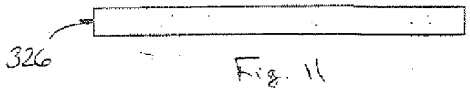

Fig. 11

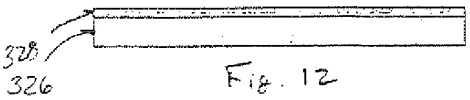

Fig. 12

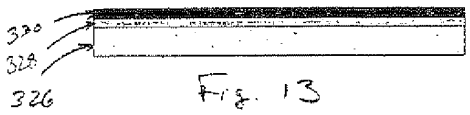

Fig. 13

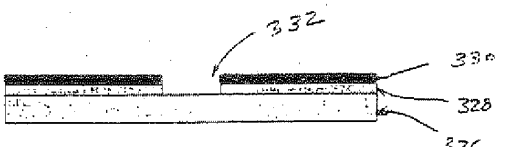

Fig. 14

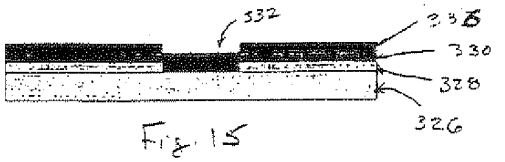

Fig. 15

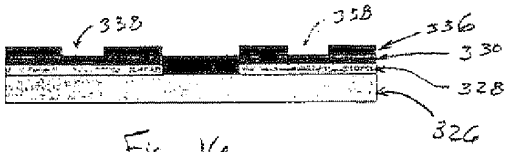

Fig. 16

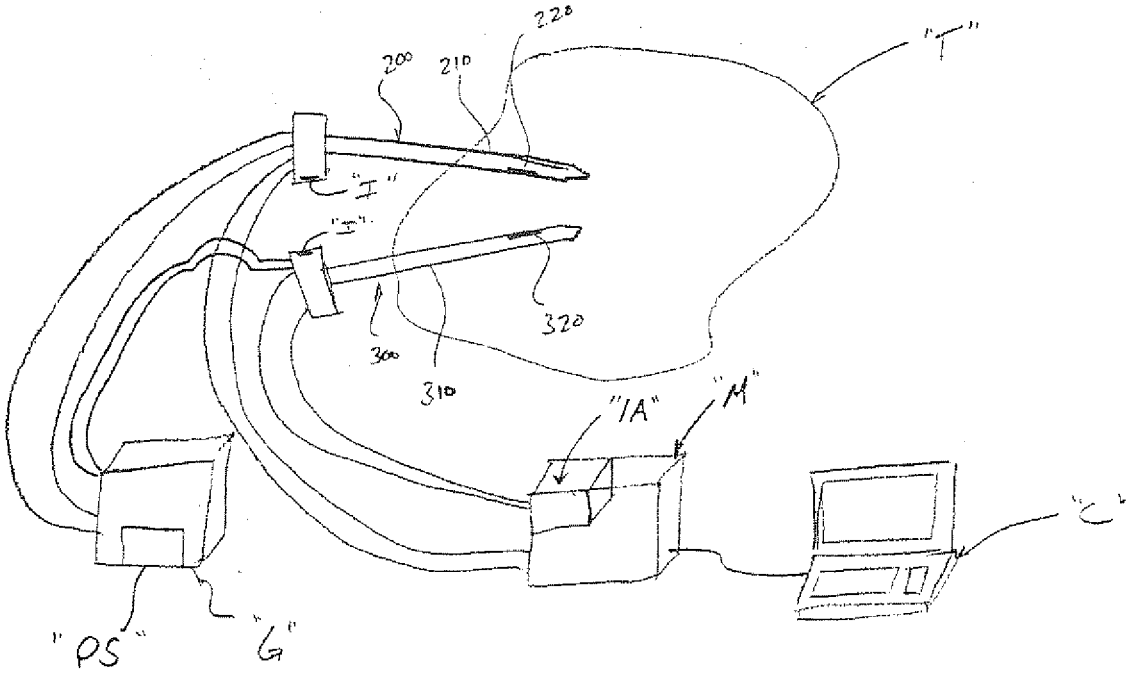
220
200
210
"T"
"I"
"I"
320
300
310
"IA"
"M"
"C"
"PS"
"G"

Fig. 17

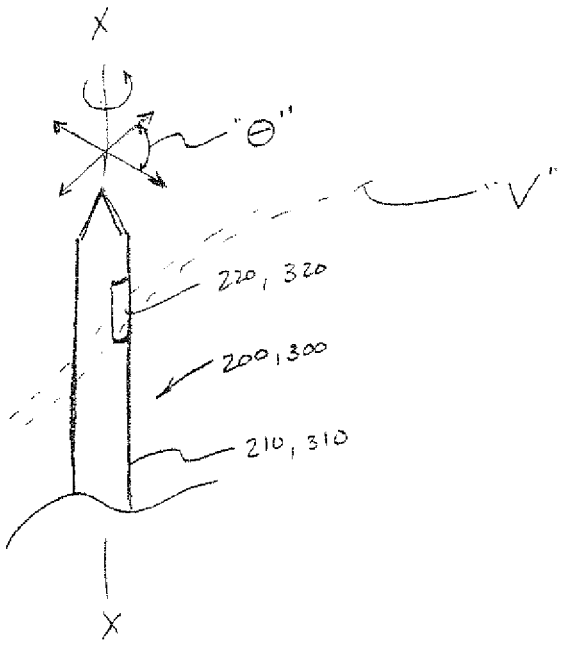
X
"θ"
"V"
220, 320
200, 300
210, 310
X

Fig. 18

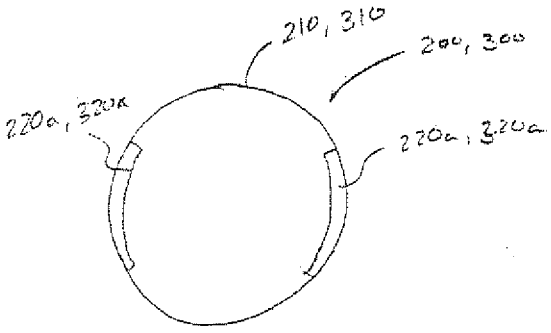

Fig. 19

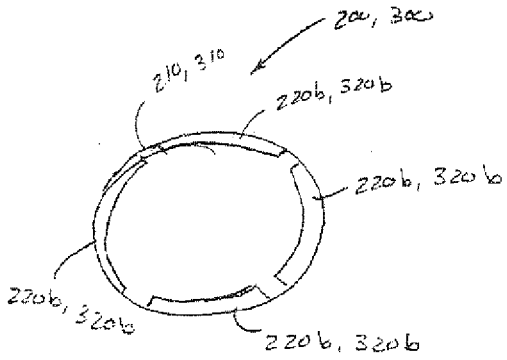

Fig. 20

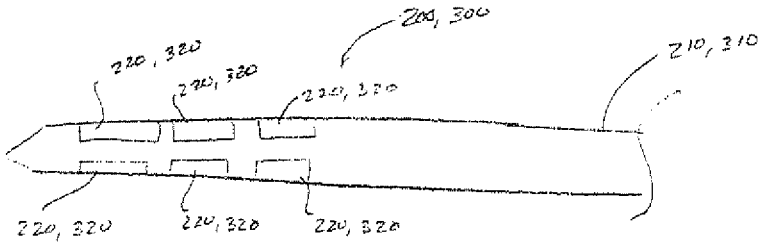

Fig. 21

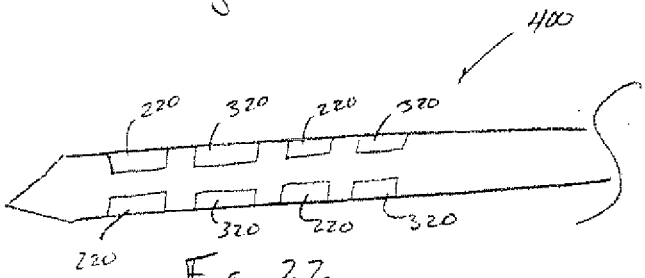

Fig. 22

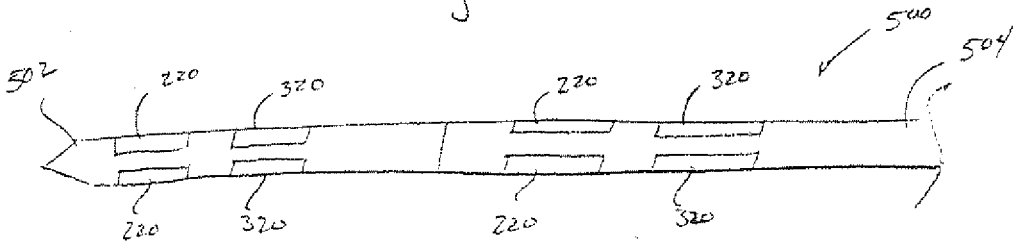

Fig. 23

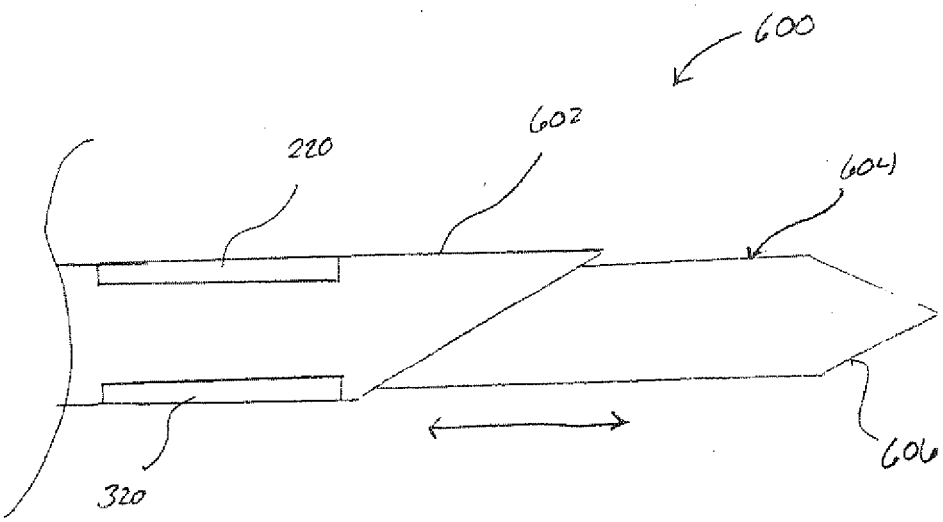

FIG. 24

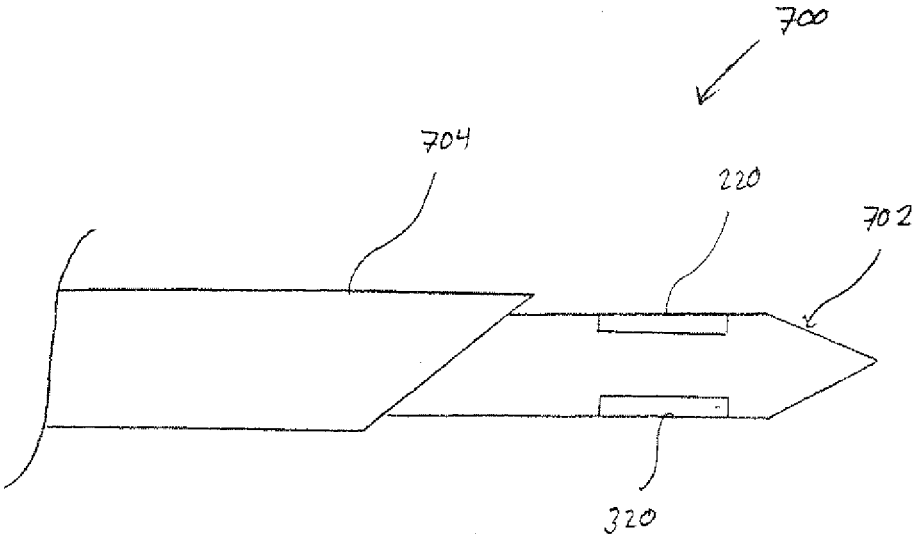

FIG. 25

REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- *Proceedings of IMECE2005 2005 ASME International Mechanical Engineering Congress and Exposition,* 05 November 2005 **[0006]**
- **S. WEINBAUM ; L.M. JIJI.** A new simplified equation for the effect of blood flow on local average tissue temperature. *ASME J. Biomech. Eng.,* 1985, vol. 107, 131-139 **[0029]**

专利名称(译)	导热率探针及其制造方法		
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申请(专利权)人(译)	泰科医疗集团，LP		
当前申请(专利权)人(译)	COVIDIEN LP 科罗拉多大学，法人团体凯欣		
[标]发明人	MAHAJAN ROOP L YI MING PODHAJSKY RONALD J PANCHAWAGH HRISHIKESH V		
发明人	MAHAJAN, ROOP L. YI, MING PODHAJSKY, RONALD J. PANCHAWAGH, HRISHIKESH V.		
IPC分类号	A61B5/053 A61B5/00 G01N27/04 G01N25/18 G01N27/18		
CPC分类号	A61B5/01 A61B5/053 A61B18/12 A61B34/10 A61B2017/00026 A61B2018/00875 G01N25/18 G01N27/045 G01N27/18 Y10T29/49 Y10T29/49002 Y10T29/49007 A61B5/0538 A61B5/055 A61B6/032 A61B6/487 A61B6/5211 A61B8/5215 A61B18/02 A61B18/1815 A61B18/20		
优先权	60/881238 2007-01-19 US		
其他公开文献	EP2402741A3 EP2402741A2		
外部链接	Espacenet		

摘要(译)

根据本公开，提供了一种用于在至少一个方向上感测组织属性的系统。该系统包括导热探针，该导热探针具有被配置为在至少一个方向上测量靶组织中的导热率的传感器，以及具有传感器的导电探针，该传感器被配置为在至少一个方向上测量靶组织中的导电率，功率供应可操作地耦合到导热探针并被配置为向导热探针供电，阻抗分析器可操作地耦合到导电探针，以及计算机可操作地耦合到电源，万用表和阻抗中的至少一个分析仪。