US 20060004257A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2006/0004257 A1

Gilad et al. (43) Pub. Date: Jan. 5, 2006

(54) IN VIVO DEVICE WITH FLEXIBLE CIRCUIT BOARD AND METHOD FOR ASSEMBLY THEREOF

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(21) Appl. No.: **10/879,054**

(22) Filed: **Jun. 30, 2004**

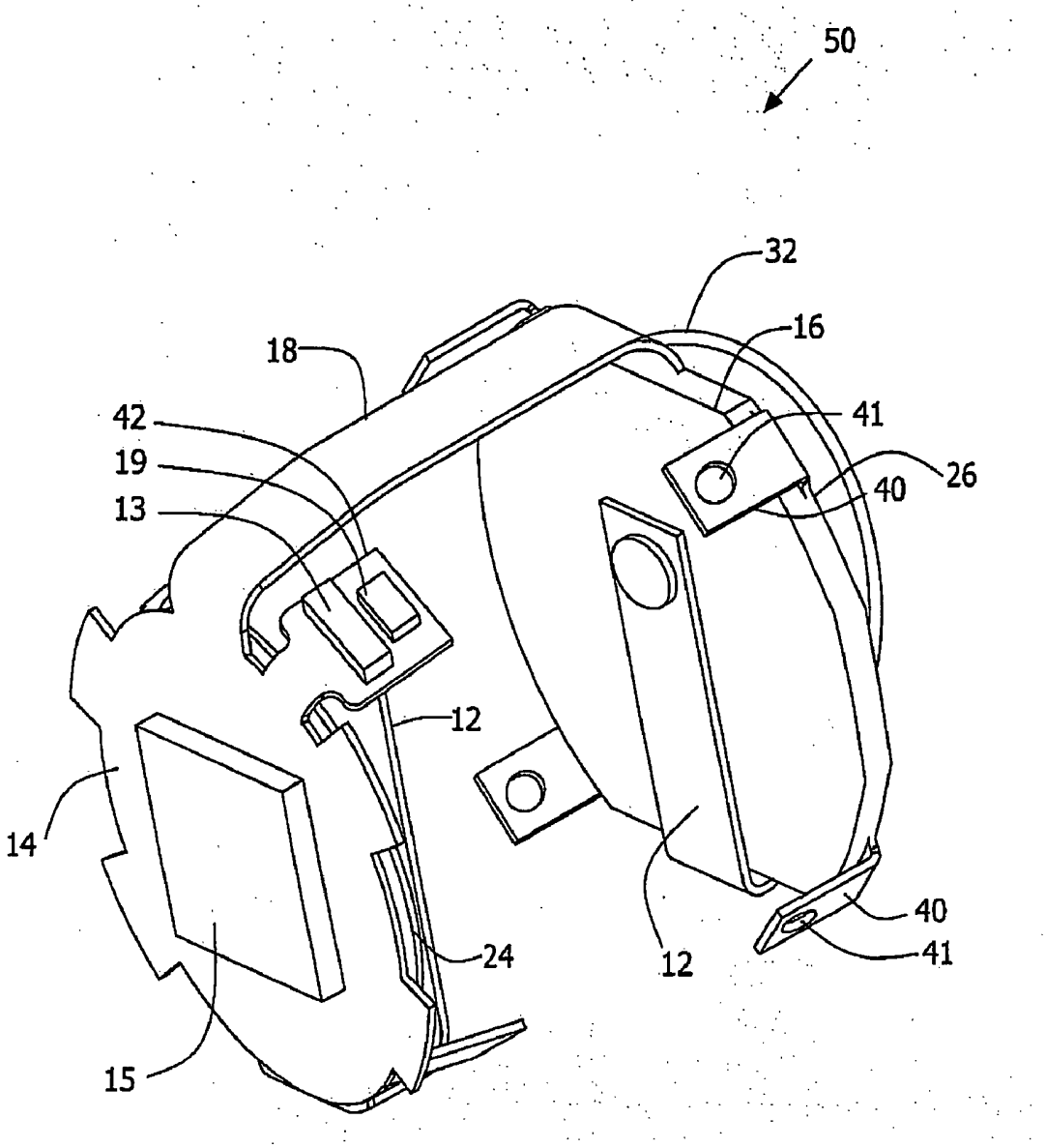
Publication Classification

(51) **Int. Cl.**
A61B 1/04 (2006.01)
A61B 5/00 (2006.01)

(52) **U.S. Cl.** **600/160**; 600/109; 600/300

(57) **ABSTRACT**

An in vivo imaging device having a flexible circuit board, for example, a one-sheet flexible circuit board. The flexible circuit board may enable folding components attached to the flexible circuit board according to a predefined angle.



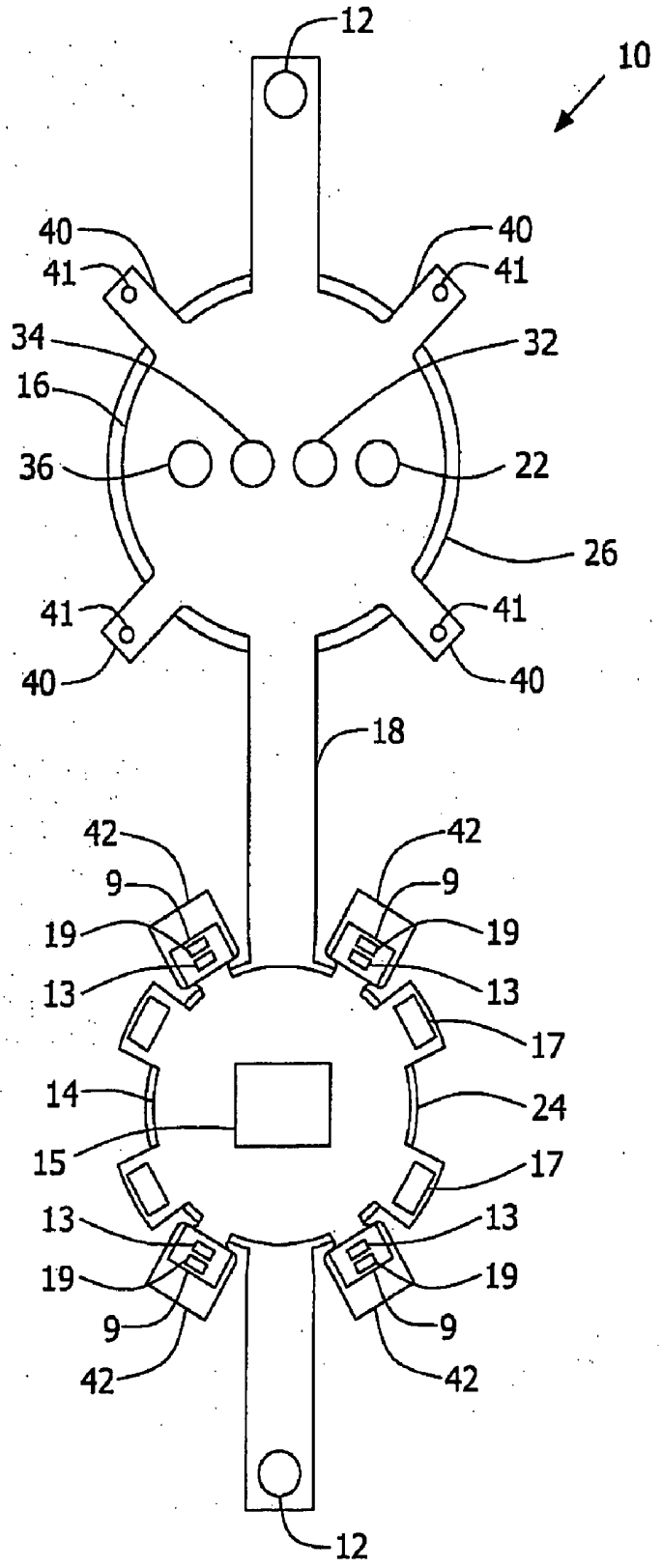

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Fig. 1

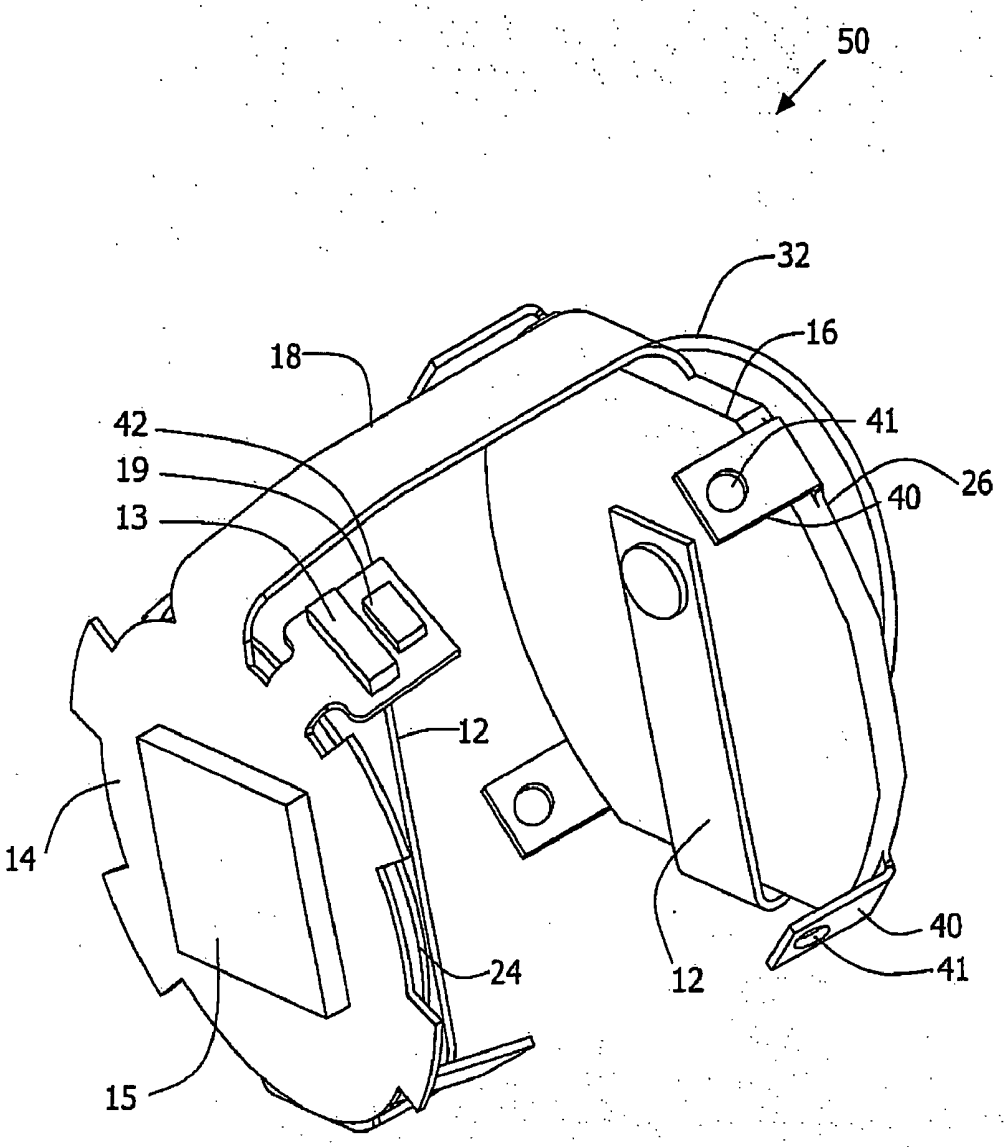

Fig. 2

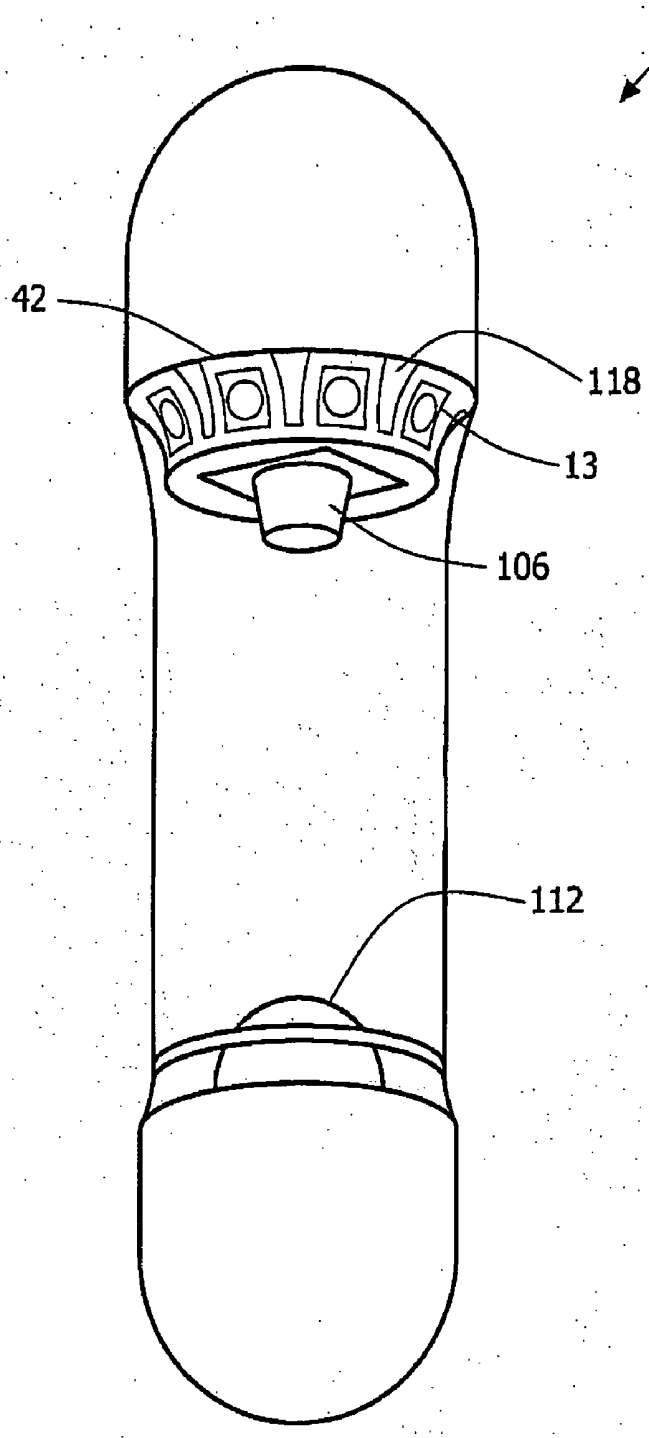

Fig. 3

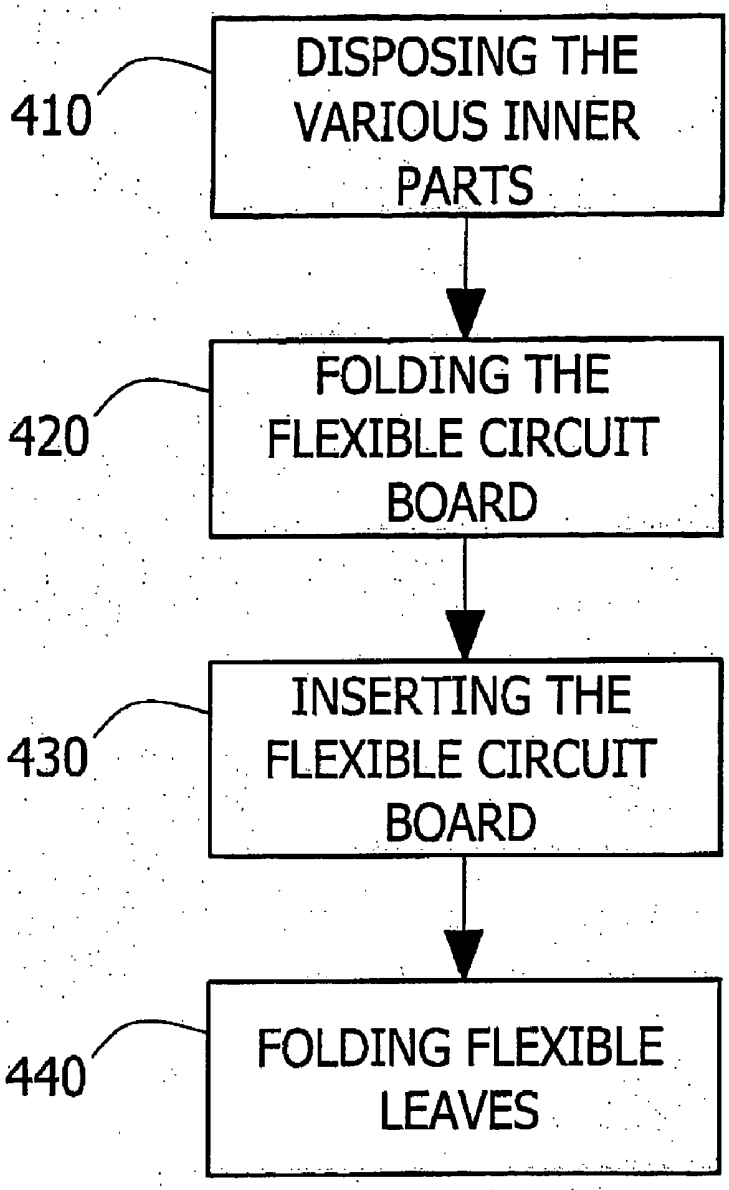
410
DISPOSING THE VARIOUS INNER PARTS
420
FOLDING THE FLEXIBLE CIRCUIT BOARD
430
INSERTING THE FLEXIBLE CIRCUIT BOARD
440
FOLDING FLEXIBLE LEAVES

Fig. 4

IN VIVO DEVICE WITH FLEXIBLE CIRCUIT BOARD AND METHOD FOR ASSEMBLY THEREOF

FIELD OF THE INVENTION

[0001] The present invention relates to an in vivo device, such as an imaging device, and a method for manufacture thereof.

BACKGROUND OF THE INVENTION

[0002] Devices helpful in providing in-vivo imaging are known in the field. Autonomous in-vivo imaging devices, such as swallowable or ingestible capsules or other devices may move through a body lumen, imaging as they move along. In vivo imaging may require in-vivo illumination, for example, using one or more LEDs or other suitable sources positioned inside an in-vivo imaging device.

[0003] In some ingestible devices the electronic components within the device may be arranged on several boards, each board containing different components of the device. The image sensor, for example a silicon chip, may be positioned on one board whereas a transmitter for transmitting images may be positioned on a separate printed circuit board (PCB).

[0004] In some cases the different components must be aligned so that certain parts are positioned at specific angles for optimal operation to be achieved.

[0005] In some cases the boards are arranged along an axis of the device and are electrically connected by one or more wires. The assembly of devices having several boards connected by wires may be complex and may hinder, for example, large scale production.

SUMMARY OF THE INVENTION

[0006] Thus the present invention provides, according to some embodiments, an in vivo device such as an imaging device including a one sheet circuit board According to one embodiment the circuit board may include at least one leaf (for example, a tongue-shaped component). Other numbers of sheets or leaves may be used. According to an embodiment of the invention a unique shape and various folding options of the leaves may enable folding and positioning of components attached to the flexible circuit board according to, for example, a predefined angle.

[0007] Optionally, the in vivo imaging device may include at least an image sensor and an illumination source. According to another embodiment the device may also include a transmitter for transmitting signals from a sensor, such as an image sensor, to a receiving system. In one embodiment various components in the device, such as the image sensor and illumination source, may be disposed on different flexible circuit board sections, for example, on the flexible leaves.

[0008] According to an embodiment, the circuit board may be folded and arranged in a stacked vertical fashion.

[0009] Additionally, upon folding and inserting the flexible circuit board into the device the leaves may be folded in an angle required for the illumination sources mounted on the leaves to provide illumination as needed. For example, a number of illumination sources mounted on the leaves may fold such that outwards panoramic illumination is achieved.

[0010] In another embodiment different components of the system may be mounted on the circuit board and may be folded as necessary.

[0011] In another embodiment the circuit board may be capable of folding according to several designs, enabling the circuit board to fit into devices of different shapes and/or sizes.

[0012] Additionally, the device and method of some embodiments of the present invention may enable easy access to key components of the device even after their assembly and incorporation into the system.

[0013] Additionally, the device and method of some embodiments of the present invention may enable exact and meticulous assembly, finish and performance while keeping maintenance and costs of the parts at a minimum.

[0014] Additionally, embodiments of the present invention may enable assembly of parts to create a variety of shapes.

[0015] Additionally, the device according to embodiments of the present invention may be lightweight and flexible, enabling quick transformation and adjustment of shape and function according to the specific needs and requirement of the procedure performed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The principles and operation of the system, apparatus, and method according to the present invention may be better understood with reference to the drawings, and the following description, it being understood that these drawings are given for illustrative purposes only and are not meant to be limiting, wherein:

[0017] **FIG. 1** is a schematic illustration showing an exemplary embodiment of a one sheet flexible circuit board in its spread out form, before it is folded and inserted into a device, according to one embodiment of the invention;

[0018] **FIG. 2** schematically illustrates possible folding of the flexible circuit board according to one embodiment of the invention;

[0019] **FIG. 3** shows a schematic illustration of an in-vivo imaging device according to one embodiment of the invention; and

[0020] **FIG. 4** is a flowchart depicting a method for producing an in vivo device which includes a flexible circuit board, according to embodiments of the invention.

[0021] It should be noted that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity. Furthermore, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements throughout the serial views.

DETAILED DESCRIPTION OF THE INVENTION

[0022] The following description is presented to enable one of ordinary skill in the art to make and use the invention

as provided in the context of a particular application and its requirements. Various modifications to the described embodiments will be apparent to those with skill in the art, and the general principles defined herein may be applied to other embodiments. Therefore, the present invention is not intended to be limited to the particular embodiments shown and described, but is to be accorded the widest scope consistent with the principles and novel features herein disclosed. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

[**0023**] Illumination sources used with embodiments of the present invention may include, for example, Light Emitting Diodes (LEDs), incandescent sources, or other suitable light sources that may enable in-vivo illumination, and may encompass devices providing electromagnetic radiation within the visible spectrum, outside of the visible spectrum, and further a combination of visible and non-visible electromagnetic radiation.

[**0024**] Some embodiments of the present invention are directed to a typically swallowable in-vivo device that may be used for recording and transmitting in vivo data, such as, for example, from the entire length of the gastrointestinal (GI) tract, to a receiving and/or processing unit. Other embodiments need not be swallowable or autonomous, and may have other shapes or configurations. According to some embodiments the in vivo device may include an image sensor, however, other sensors may be used. Devices according to embodiments of the present invention may be similar to embodiments described in International Application WO 01/65995 and/or in U.S. Pat. No. 5,604,531, each of which are assigned to the common assignee of the present invention and each of which are hereby incorporated by reference in their entirety. Furthermore, receiving, storage, processing and/or display systems suitable for use with embodiments of the present invention may be similar to embodiments described in WO 01/65995 and/or in U.S. Pat. No. 5,604,531. Of course, devices, systems, structures, functionalities and methods as described herein may have other configurations, sets of components and processes etc.

[**0025**] Reference is now made to **FIG. 1** showing an exemplary embodiment of a one sheet flexible circuit board **10** in its spread out form, before it is folded and inserted into an in-vivo device, for example, a capsule, according to an embodiment of the invention. Devices having forms other than capsules may be used. According to some embodiments the flexible circuit board **10** may be a printed circuit board (PCB) made of, for example, silicone or plastic. Other suitable materials may be used. In one embodiment of the invention flexible circuit board **10** may include one or more battery contacts **12**, for example, placed at each end, and one or more (e.g., two) wider portions **14** and **16**, connected to one another by means of a narrowed flexible circuit board strip **18**. Underneath each flexible portion **14** and **16**, a rigid portion **24** and **26** may be attached, respectively, enabling, for example, the stability of the components each portion holds. According to one embodiment a portion or section of the circuit board may have a set of components mounted or disposed upon it. According to one embodiment portion **16** of the circuit board, for example, may include components such as a switch **34**, a transmitter, processor or controller such as an ASIC (Application Specific Integrated Circuit) **36**, a silicon timer **22** and an antenna **32**, while the other portion **14** of the circuit board **10** may have an imaging system **11**, for example, for obtaining images from inside a body lumen, mounted upon it. Other components and sets of components may be used. The imaging system may include one or more illumination units **9**, an image sensor such as an imaging camera **15** and for example one or more capacitors **17**. The illumination unit **9** may include one or more illumination sources **13**, such as white LEDs, and one or more resistors **19**. According to one embodiment the circuit board components may be arranged on one side of the circuit board **10**, enabling comfortable accessibility during a device production process. In alternate embodiments, other components layouts may be arranged on a flexible circuit board with a different shape.

[**0026**] According to one embodiment of the present invention, as seen, for example, with reference to **FIG. 1**, flexible leaves **42** and **40** may be formed, respectively, of the circuit board portions **14** and **16**, including different components. According to one embodiment flexible leaves **40** protruding from flexible portion **16** may comprise for example test points **41**, while flexible leaves **42** protruding from flexible circuit board **14** may include one or more illumination units **9**. Each illumination unit **9** may comprise, for example, at least one illumination source **13** and resistors **19**. Flexible leaves **42** protruding from portion **14** may be folded inwards at a required angle when the flexible circuit board **10** is inserted into a housing tube, for example a capsule housing tube (as will be described, for example, with reference to **FIG. 2**). The shape and proportions of the device housing may determine the exact angle in which each flexible leave **42** will fold upon insertion of the circuit board. According to one embodiment the angles thus created, enable the illumination units **13**, mounted on the leaves **42**, to create the specific field and angle of illumination required.

[**0027**] In addition, flexible leaves **40** protruding from portion **16** may also be folded inwards at a required angle when the flexible circuit board is inserted into a housing tube.

[**0028**] According to one embodiment, a flexible circuit board **10** length in its spread out form may be equal to or less than about 36.5 mm (measured between the centers of battery contacts **12**) while its breadth may be less or more than about 13 mm (measured between the edges of flexible portions **14** and **16**). Such a flexible circuit board may be suitable for use in a device that is about 20-30 mm long. Flexible circuit boards and micro technology according to embodiments of the invention may be similar to flexible boards produced by Al-tech of Petach-Tikva, Israel. Other dimensions or sizes may be used.

[**0029**] Reference is now made to **FIG. 2** showing an exemplary embodiment of a flexible circuit board **50** shape after it has been folded and inserted into an in vivo device, for example, a capsule. While the invention is shown in use with a capsule, other in-vivo devices may house embodiments of the invention, and devices may be used having other con figurations (e.g., spherical, rounded, an endoscope, etc.). According to one embodiment of the present invention,

flexible circuit board portions **14** and **16** may be folded upon insertion so that they are facing each other resulting in for example a "C" shape. In this folded state, according to one embodiment, antenna **32** and an imaging device such as imaging camera **15** are facing outwards while battery contacts **12** are folded under flexible portions **14** and **16** which may, according to some embodiments, having rigid portions **24** and **26** attached to them, for example, so that contact may be made with a set of batteries which may be sandwiched between circuit board portions **16** and **14**. According to one embodiment, flexible leaves **42** holding illumination sources **13** and resistors **19** may, for example bend in a range of degrees upon inserting the flexible circuit board into a device housing tube so as to enable, for example, an outwards illumination at different angles. The illumination angle may be determined by for example the housing tube shape. In another embodiment of the present invention, test points **41** placed on flexible leaves **40**, may be folded inwards so as to allow a better space utilization in a device. In some embodiments of the present invention, various components may be sandwiched between or otherwise disposed between circuit board portions.

[**0030**] The folding of the leaves **40** upon which the test points **41** are mounted may enable preservation of the test points without wasting any valuable space. This method of preserving the test points instead of cutting and removing them, prior to packaging the circuit board into a device, may save time and may reduce the risk of short circuiting the system as is often the case in systems where the test points need to be cut off and removed prior to use. According to an embodiment the flexible circuit board **50** offers little manufacturing and assembly hindrances such as delicate and expensive welding of parts, sophisticated manufacturing protocols etc.

[**0031**] Different arrangements may determine the exact folding of the flexible circuit board and components, enabling different angles and scopes of, for example, illumination and camera rotation. Different folding options of the flexible circuit board may free up more space in accordance with the number of mounted and loose components that need to be housed within a device shell.

[**0032**] In one embodiment the flexible circuit board may be incorporated into a device such as a panoramic field of view imaging device, for example, as shown schematically in **FIG. 3**. Other suitable imaging or sensing devices, including or not including panoramic viewing, may be used with embodiments of the present invention. Device **100** may include for example a transmitter, a processor, a receiver, an Image sensor **106**, a power supply, one or more illuminators **13** and a reflective element such as for example a mirror or a curved mirror **112**. According to some embodiments, other sensors except an image sensor may be used e.g., a temperature sensor, a pH sensor, a pressure sensor, an electrical impedance sensor, sensors of physiological parameters of the body lumen, etc.

[**0033**] According to one embodiment, for example as shown in **FIG. 3**, illumination sources **13** may be on flexible circuit board leaves **42** slanted outward in relation to the plane of an image sensor **106**.

[**0034**] In one embodiment the flexible circuit board leaves **42** are part of a flexible circuit board **10**. In another embodiment, some components need not be situated on the flexible circuit board, for example illumination sources **13** may be situated, for example, on an outward facing ring **118** such that illuminators face outward and away from image sensor.

[**0035**] A method for producing an in vivo imaging device which includes a flexible circuit board **10**, according to different embodiments of the invention is depicted in **FIG. 4**.

[**0036**] Step **410** according to some embodiments includes placing various inner parts of the device on a flexible circuit board (e.g., board **10**). For example, a switch **34**, an ASIC (Application Specific Integrated Circuit) **36** and a silicon timer **22** may be disposes on flexible section **16** (as was described with reference to **FIG. 1**). Other specific components may be Used. Step **420** includes, for example, folding portions of the flexible circuit board (e.g., portions **14** and **16**) so that they are "C" shaped, facing each other (as was described with reference to **FIG. 2**). Other suitable configurations and folding arrangements can be used.

[**0037**] According to one embodiment of the present invention, in step **430** the flexible circuit board, may be inserted into a housing, for example a device housing tube. According to one embodiment, in step **440** flexible leaves which may be protruding from portions **14** and **16** may be folded inwards at a required angle when the flexible circuit board is inserted into a housing tube.

[**0038**] The foregoing description of the embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. It should be appreciated by persons skilled in the art that many modifications, variations, substitutions, changes, and equivalents are possible in light of the above teaching. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

1. An in vivo imaging device comprising a flexible circuit board.

2. The device according to claim 1, wherein said imaging device is an autonomous in-vivo imaging device.

3. The device according to claim 1, wherein said flexible circuit board consists of one sheet.

4. The device according to claim 1, wherein at least one rigid section is attached to said flexible circuit board.

5. The device according to claim 1, wherein the flexible circuit board comprises at least one flexible leaf.

6. The device according to claim 5, wherein said at least one flexible leaf is folded at a required angle in relation to an axis of said in vivo imaging device.

7. The device according to claim 6, wherein said angle is determined by the device housing.

8. The device according to claim 1, wherein said flexible circuit board is a PCB.

9. The device according to claim 1 comprising a sensor.

10. The device according to claim 9, wherein said sensor is an image sensor.

11. The device according to claim 9, wherein the sensor is selected from the group consisting of a pH sensor, a temperature sensor, an electrical impedance sensor and a pressure sensor.

12. The device according to claim 1, comprising at least one component selected from the group consisting of: an

illumination unit, a power source, a processor, a receiver, a transmitter or a combination thereof.

13. The device according to claim 12, wherein at least one component is disposed on at least one section of said flexible circuit board.

14. The device according to claim 5, wherein at least one component is disposed on a flexible leaf.

15. The device according to claim 5, comprising an illumination unit disposed on said flexible leaf.

16. The device according to claim 1, comprising battery contacts.

17. The device according to claim 16, wherein said battery contacts are folded under a section of the flexible circuit board.

18. The device according to claim 1, wherein a power source is disposed between two flexible sections of the flexible circuit board.

19. The device according to claim 1, wherein a sensor is disposed on one section of said flexible circuit board and a transmitter is disposed on another section of said flexible circuit board.

20. The device according to claim 4, wherein said circuit board is folded such that said rigid sections are stacked.

21. The device according to claim 1, wherein said circuit board is folded such that sections of the circuit board are stacked.

22. The device according to claim 1 wherein said flexible circuit board holds an illumination source at a required angle in order to illuminate a selected field of view.

23. A method for the manufacture of an in vivo sensing device, the method comprising the steps of:

disposing at least a sensor on a section of a flexible circuit board, said circuit board having at least one flexible leaf; and

folding said flexible circuit board into a device housing.

24. The method according to claim 23, wherein the step of folding the circuit board includes folding the circuit board such that sections of said flexible circuit board are stacked.

25. The method according to claim 23, wherein said flexible leaf comprises an illumination unit.

26. The method according to claim 23, wherein said flexible leaf comprises at least one test point.

27. The method according to claim 23 comprising folding said flexible leaf at an angle relative to the circuit board.

28. A method for producing an in vivo imaging device, said device having an outer shell, the method comprising:

folding into the outer shell a flexible circuit board, said circuit board comprising at least a sensor.

29. The method according to claim 28 comprising the step of folding flexible leaves of the flexible circuit board.

30. The method according to claim 29 comprising the step of positioning an illumination unit on said flexible leaf.

31. The method according to claim 28 comprising the step of adding to the outer shell an optical dome.

32. The method according to claim 28 comprising the step of inserting into the shell at least one battery.

33. An in vivo sensing device comprising a set of components mounted on a flexible circuit board, wherein the circuit board is folded within the sensing device.

34. The device of claim 33, wherein the device is autonomous.

35. The device of claim 33, comprising an image sensor.

36. The device of claim 33, wherein a set of components are disposed between two sections of the circuit board.

* * * * *

专利名称(译)	具有柔性电路板的体内装置及其组装方法		
公开(公告)号	US20060004257A1	公开(公告)日	2006-01-05
申请号	US10/879054	申请日	2004-06-30
[标]申请(专利权)人(译)	吉拉德ZVIKA KHAIT SEMION		
申请(专利权)人(译)	吉拉德ZVIKA KHAIT SEMION		
当前申请(专利权)人(译)	基文影像有限公司.		
[标]发明人	GILAD ZVIKA KHAIT SEMION		
发明人	GILAD, ZVIKA KHAIT, SEMION		
IPC分类号	A61B1/04 A61B5/00		
CPC分类号	A61B1/04 H05K1/189 A61B1/041		
其他公开文献	US8500630		
外部链接	Espacenet USPTO		

摘要(译)

一种体内成像装置，具有柔性电路板，例如，单片柔性电路板。柔性电路板可以使得能够根据预定角度折叠附接到柔性电路板的部件。