

**CLAIMS**

~~1. An electrode assembly patch attachable to an intravascular device, the electrode assembly patch comprising:~~

~~a strip extending from a proximal end to a distal end;~~

~~a first electrode tab extending outwardly and away from the strip, the first electrode tab configured to provide a current to an ambient fluid;~~

~~a second electrode tab spaced from the first electrode tab, the second electrode tab extending outwardly and away from the strip, the second electrode tab configured to measure voltage in the ambient fluid;~~

~~a third electrode tab spaced from the second electrode tab, the third electrode tab extending outwardly and away from the strip, the third electrode tab configured to measure voltage in the ambient fluid; and~~

~~a fourth electrode tab spaced from the third tab, the fourth electrode tab extending outwardly and away from the strip, the fourth electrode tab configured to provide a current to the ambient fluid.~~

~~2. The electrode assembly patch of claim 1, wherein the first, second, third, and fourth electrode tabs extend outwardly and away from a first side of the strip in a first direction.~~

~~3. The electrode assembly patch of claim 2, further comprising:~~

~~a first stabilizing tab extending outwardly and away from a second side of the strip in a second direction opposite the first direction; and~~

~~a second stabilizing tab spaced from the first stabilizing tab and extending outwardly away from the strip in the second direction.~~

~~4. The electrode assembly patch of claim 3, wherein the first stabilizing tab is positioned laterally in between the first and second electrode tabs.~~

~~5. The electrode assembly patch of claim 4, wherein the second stabilizing tab is positioned laterally between the third and fourth electrode tabs.~~

~~6. The electrode assembly patch of one of claims 1 to 5, wherein the electrode assembly patch is configured to be flexible.~~

~~7. The electrode assembly patch of one of claims 1 to 6, wherein the electrode assembly patch is configured to have a two-dimensional configuration in an undeployed state and wherein the electrode assembly patch is further configured to have a three-dimensional configuration in a deployed state.~~

~~8. The electrode assembly patch of claims 1 to 7, wherein each of the first, second, third, and fourth electrode tab includes an electrode extending in the tab.~~

~~9. The electrode assembly patch of claim 8, wherein the electrode includes one or both of gold or platinum.~~

~~10. The electrode assembly patch of one of claims 1 to 8, wherein the second tab is spaced apart from the first tab by a first distance, the third tab is spaced apart from the second tab by a second distance, and the fourth tab is spaced apart from the third tab by the first distance.~~

~~11. The electrode assembly patch of claim 10, wherein the second distance is greater than the first and third distances.~~

~~12. The electrode assembly patch of one of claims 3 to 11, wherein each of the first, second, third and fourth electrode tabs and each of the first and second stabilizing tabs extend perpendicular to the strip.~~

~~13. The electrode assembly patch of one of claims 3 to 12, wherein a width of the first stabilizing tab is less than or equal to a first lateral distances between the first and second electrode tabs and wherein a width of the second stabilizing tab is less than or equal to a second lateral distance between the third and fourth electrode tabs.~~

~~14. The electrode assembly patch of one of claims 1 to 13, wherein the patch includes four layers, each layer having a thickness of 5  $\mu\text{m}$ .~~

~~15. A system for determining an admittance or conductance, the system comprising:  
~~-an intravascular device configured to be inserted into a patient's heart; and~~  
~~-a flexible electrode assembly patch attached to at least a portion of the intravascular device,~~  
 wherein the flexible electrode assembly patch includes two or more electrodes configured to determine an admittance and/or conductance.~~

~~16. The system of claim 15, wherein the flexible electrode assembly patch includes:  
 a strip extending from a proximal end to a distal end;  
 a first electrode tab extending outwardly and away from the strip, the first electrode tab configured to provide a current to an ambient fluid;  
 a second electrode tab spaced from the first electrode tab, the second electrode tab extending outwardly and away from the strip, the second electrode tab configured to measure voltage in the ambient fluid;  
 a third electrode tab spaced from the second electrode tab, the third electrode tab extending outwardly and away from the strip, the third electrode tab configured to measure voltage in the ambient fluid; and  
 a fourth electrode tab spaced from the third tab, the fourth electrode tab extending outwardly and away from the strip, the fourth electrode tab configured to provide a current to the ambient fluid.~~

~~17. The system of claim 16, wherein the first, second, third, and fourth electrode tabs extend outwardly and away from a first side of the strip in a first direction.~~

~~18. The system of claim 17, further comprising:  
a first stabilizing tab extending outwardly and away from a second side of the strip in a second direction opposite the first direction; and  
a second stabilizing tab spaced from the first stabilizing tab and extending outwardly away from the strip in the second direction.~~

~~19. The system of claim 15 to 18, wherein the flexible electrode assembly patch includes a strip having a proximal end and a distal end.~~

~~20. The system of one of claims 15 to 19, further comprising:  
a controller electrically connected to the electrode assembly patch, the controller comprising:  
a current source;  
a memory; and  
one or more processors coupled to the memory and configured to:  
provide an alternating current to electrodes of the first electrode tab and the fourth electrode tab;  
measure voltages through electrodes of the second electrode tab and the third electrode tab; and  
determine an admittance or a conductance based on the measured voltages of the second tab and the third tab.~~

21. A system (300) for determining an admittance or conductance, the system comprising:  
an intravascular device (318) configured to be inserted into a patient's heart; and  
an electrode assembly patch (320, 400, 600, 700, 800) attached to at least a portion of the intravascular device (318), wherein the electrode assembly patch (320, 400, 600, 700, 800) includes a multi-layered construction comprising:  
a first non-conductive layer configured to adhered to the portion of the intravascular device;  
a second layer having one or more wires (456a-456d);  
a third non-conductive layer configured to electrically insulate the one or more wires (456a-456d); and  
a fourth layer including one or more electrodes (454a-454d).

22. The system (300) of claim 21, wherein the first non-conductive layer may be formed from a polymer material configured to be glued, bonded and/or thermoformed to the portion of the intravascular device (318).

23. The system (300) of claim 21 or 22, wherein each of the one or more wires (456a-456d) are spaced apart by a non-conductive material.
24. The system (300) of one of claims 21 to 23, wherein the one or more wires (456a-456d) are formed from a conductive material.
25. The system (300) of claim 24, wherein the conductive material includes platinum, gold, silver, and/or copper.
26. The system (300) of one of claims 21 to 25, wherein the one or more electrodes (454a-454d) in the fourth layer are at least partially exposed.
27. The system (300) of one of claims 21 to 26, wherein the multi-layered construction includes four sandwiched layers.
28. The system (300) of one of claims 21 to 27, wherein the layers are glued, bonded, and/or thermoformed together.
29. The system (300) of one of claims 21 to 28, wherein the electrode assembly patch (320, 400, 600, 700, 800) includes:
  - a strip (404, 604, 704, 804) extending from a proximal end (402, 602, 702, 802) to a distal end (408, 608, 708, 808);
  - a first electrode tab (406a, 606a, 706a, 806a) extending outwardly and away from the strip (404, 604, 704, 804), the first electrode tab configured to provide a current to an ambient fluid;
  - a second electrode tab (406b, 606b, 706b, 806b) spaced from the first electrode tab (406a, 606a, 706a, 806a), the second electrode tab (406b, 606b, 706b, 806b) extending outwardly and away from the strip (404, 604, 704, 804), the second electrode tab (406b, 606b, 706b, 806b) configured to measure voltage in the ambient fluid;
  - a third electrode tab (406c, 606c, 706c, 806c) spaced from the second electrode tab (406b, 606b, 706b, 806b), the third electrode tab (406c, 606c, 706c, 806c) extending outwardly and away from the strip (404, 604, 704, 804), the third electrode tab (406c, 606c, 706c, 806c) configured to measure voltage in the ambient fluid; and
  - a fourth electrode tab (406d, 606d, 706d, 806d) spaced from the third electrode tab (406c, 606c, 706c, 806c), the fourth electrode tab (406d, 606d, 706d, 806d) extending outwardly and away from the strip (404, 604, 704, 804), the fourth electrode tab (406d, 606d, 706d, 806d) configured to provide a current to the ambient fluid.
3010. The system (300) of claim 29, wherein the first (406a, 606a, 706a, 806a), second (406b, 606b, 706b, 806b), third (406c, 606c, 706c, 806c), and fourth electrode tabs (406d, 606d, 706d, 806d) extend outwardly and away from a first side of the strip (404, 604, 704, 804) in a first direction.

- ~~3111.~~ The system (300) of claim ~~3010~~, further comprising:  
 a first stabilizing tab (408a, 608a) extending outwardly and away from a second side of the strip (404, 604) in a second direction opposite the first direction; and  
 a second stabilizing tab (408b, 608b) spaced from the first stabilizing tab (408a, 608a) and extending outwardly away from the strip (404, 604) in the second direction.
12. The system (300) of claim 11, wherein a width of the first stabilizing tab (408a, 608a) is less than or equal to a first lateral distances between the first and second electrode tabs (406a, 406b, 606a, 606b) and wherein a width of the second stabilizing tab (408b, 608b) is less than or equal to a second lateral distance between the third and fourth electrode tabs (406c, 406d, 606c, 606d).
- ~~32.~~ ~~The system of one of claims 31 to 31, wherein the electrode assembly patch includes a strip having a proximal end and a distal end.~~
- ~~3313.~~ The system (300) of one of claims 9 to 16~~12~~, further comprising:  
 a controller (302) electrically connected to the electrode assembly patch (320, 400, 600, 700, 800), the controller (302) comprising:  
 a current source (314);  
 a memory (306); and  
 one or more processors (304) coupled to the memory (306) and configured to:  
 provide an alternating current to electrodes (454a-454d) of the first electrode tab (406a) and the fourth electrode tab (406d);  
 measure voltages through electrodes (454a-454d) of the second electrode tab (406b) and the third electrode tab (406c); and  
 determine an admittance or a conductance based on the measured voltages of the second electrode tab (406b) and the third electrode tab (406c).
14. The system (300) of one of claims 9 to 13, wherein the electrode assembly patch (320, 400, 600, 700, 800) is configured to have a two-dimensional configuration in an undeployed state and wherein the electrode assembly patch (320, 400, 600, 700, 800) is further configured to have a three-dimensional configuration in a deployed state.
- ~~34. A method of forming a system for determining an admittance or conductance, the method comprising:~~
15. The system (300) of any one of claim 1 to 14, wherein each layer having a thickness of 1 to 10  $\mu\text{m}$ , wherein each layer having a thickness of preferably 5  $\mu\text{m}$ .

~~rolling and/or wrapping a flexible electrode assembly patch to at least a portion of an intravascular device configured to be inserted into a patient's heart; and~~

~~attaching the flexible electrode assembly patch to the portion of the intravascular device.~~

~~35. The method of claim 34, wherein the step of attaching includes, thermoforming the flexible electrode assembly patch to the portion of the intravascular device.~~

~~36. The method of claim 34 or 35, wherein the flexible electrode assembly patch includes a multi-layered construction.~~

~~37. The method of one of claims 34 to 36, wherein the flexible electrode assembly patch includes:~~

~~a strip extending from a proximal end to a distal end;~~

~~a first electrode tab extending outwardly and away from the strip, the first electrode tab configured to provide a current to an ambient fluid;~~

~~a second electrode tab spaced from the first electrode tab, the second electrode tab extending outwardly and away from the strip, the second electrode tab configured to measure voltage in the ambient fluid;~~

~~a third electrode tab spaced from the second electrode tab, the third electrode tab extending outwardly and away from the strip, the third electrode tab configured to measure voltage in the ambient fluid; and~~

~~a fourth electrode tab spaced from the third tab, the fourth electrode tab extending outwardly and away from the strip, the fourth electrode tab configured to provide a current to the ambient fluid.~~

~~38. The method of claim 37, wherein the first, second, third, and fourth electrode tabs extend outwardly and away from a first side of the strip in a first direction.~~

~~39. The method of claim 38, wherein the flexible electrode assembly patch further comprises:~~

~~a first stabilizing tab extending outwardly and away from a second side of the strip in a second direction opposite the first direction; and~~

~~a second stabilizing tab spaced from the first stabilizing tab and extending outwardly away from the strip in the second direction.~~

~~40. The method of one of claims 34 to 39, wherein the flexible electrode assembly patch includes a two-dimensional configuration before the flexible electrode assembly patch is rolled and/or wrapped onto the intravascular device.~~

~~41. An intravascular blood pump system, comprising:~~

~~An intravascular blood pump configured to pump blood through a cannula from a blood inlet to a blood outlet;~~

~~an electrode assembly coupled to at least a portion of the cannula, the electrode assembly comprising:~~

~~a strip extending from a proximal end to a distal end;~~

~~a first tab extending perpendicularly away from the strip, the first tab having an electrode configured to provide a current to an ambient fluid;~~

~~a second tab positioned distal of the first tab and extending perpendicularly away from the strip, the second tab configured to measure voltage in the ambient fluid;~~

~~a third tab positioned distal of the second tab and extending perpendicularly away from the strip, the third tab configured to measure voltage in the ambient fluid; and~~

~~a fourth tab positioned distal of the third tab and extending perpendicularly away from the strip, the fourth tab configured to provide a current to the ambient fluid;~~

~~a controller electrically connected to the electrode assembly, the controller comprising:~~

~~a current source;~~

~~a memory; and~~

~~one or more processors coupled to the memory and configured to:~~

~~provide an alternating current to the electrodes of the first tab and the fourth tab;~~

~~measure voltages through the electrodes of the second tab and the third tab;~~

~~and~~

~~determine an admittance or a conductance based on the measured voltages of the second tab and the third tab.~~

~~42. The system of claim 41, wherein the second tab is spaced apart distally from the first tab by a first distance, the third tab is spaced apart distally from the second tab by a second distance, and the fourth tab is spaced apart distally from the third tab by the first distance.~~

~~43. The system of claim 42, wherein the electrode assembly further comprises:~~

~~a fifth tab positioned distal of the first tab and proximal of the second tab, and extending perpendicularly away from the strip in an opposite direction from the first tab and the second tab; and~~

~~a sixth tab positioned distal of the third tab and proximal of the fourth tab, and extending perpendicularly away from the strip in an opposite direction from the third tab and the fourth tab.~~

~~44. The system of claim 43, wherein a width of the fifth tab and a width of the sixth tab are configured to be less than or equal to the first distance.~~

~~45. The system of claim 44, wherein the first distance is 3 mm.~~

~~46. The system of claim 45, wherein the width of the fifth tab and the width of the sixth tab are 2.5 mm.~~

~~47. The system of claim 45, wherein the second distance is 10 mm.~~

~~48. The system of claim 42, wherein the electrode assembly further comprises:  
a fifth tab positioned proximal of the first tab, and extending perpendicularly away from the strip in an opposite direction from the first tab and the second tab; and  
a sixth tab positioned distal of the second tab and proximal of the third tab, and extending perpendicularly away from the strip in an opposite direction from the third tab and the fourth tab.~~

~~49. The system of claim 48, wherein the first distance is 3 mm.~~

~~50. The system of claim 49, wherein a width of the fifth tab and a width of the sixth tab is 3 mm.~~

~~51. The system of claim 49, wherein the second distance is 10 mm.~~

~~52. The system of claim 41, wherein the electrode assembly is configured to be flexible.~~

~~53. The system of claim 41, wherein the electrodes of the first tab, second tab, third tab, and fourth tab comprise one or both of gold or platinum.~~

~~54. The system of claim 41, wherein the electrode assembly comprises four layers, each layer having a thickness of 5  $\mu\text{m}$ .~~

~~55. The system of claim 41, wherein the current source is configured to provide a substantially constant alternating current of 10 and 100  $\mu\text{A}$  at 20 kHz.~~

~~56. A system for determining admittance or conductance, comprising:  
An intravascular device configured to be inserted into a patient's heart;  
an electrode assembly coupled to at least a portion of the intravascular device, the electrode assembly comprising:  
a strip extending from a proximal end to a distal end;  
a first tab extending perpendicularly away from the strip, the first tab having an electrode configured to provide a current to an ambient fluid;  
a second tab positioned distal of the first tab and extending perpendicularly away from the strip, the second tab configured to measure voltage in the ambient fluid;  
a third tab positioned distal of the second tab and extending perpendicularly away from the strip, the third tab configured to measure voltage in the ambient fluid; and~~

~~a fourth tab positioned distal of the third tab and extending perpendicularly away from the strip, the fourth tab configured to provide a current to the ambient fluid;~~

~~a controller electrically connected to the electrode assembly, the controller comprising:~~

~~a current source;~~

~~a memory; and~~

~~one or more processors coupled to the memory and configured to:~~

~~provide an alternating current to the electrodes of the first tab and the fourth~~

~~tab;~~

~~measure voltages through the electrodes of the second tab and the third tab;~~

~~and~~

~~determine an admittance or a conductance based on the measured voltages of the second tab and the third tab.~~

~~57. The system of claim 56, wherein the second tab is spaced apart distally from the first tab by a first distance, the third tab is spaced apart distally from the second tab by a second distance, and the fourth tab is spaced apart distally from the third tab by the first distance.~~

~~58. The system of claim 57, wherein the electrode assembly further comprises:~~

~~a fifth tab positioned distal of the first tab and proximal of the second tab, and extending perpendicularly away from the strip in an opposite direction from the first tab and the second tab; and~~

~~a sixth tab positioned distal of the third tab and proximal of the fourth tab, and extending perpendicularly away from the strip in an opposite direction from the third tab and the fourth tab.~~

~~59. The system of claim 58, wherein a width of the fifth tab and a width of the sixth tab are configured to be less than or equal to the first distance.~~

~~60. The system of claim 59, wherein the first distance is 3 mm.~~

~~61. The system of claim 60, wherein the width of the fifth tab and the width of the sixth tab are 2.5 mm.~~

~~62. The system of claim 60, wherein the second distance is 10 mm.~~

~~63. The system of claim 57, wherein the electrode assembly further comprises:~~

~~a fifth tab positioned proximal of the first tab, and extending perpendicularly away from the strip in an opposite direction from the first tab and the second tab; and~~

~~a sixth tab positioned distal of the second tab and proximal of the third tab, and extending perpendicularly away from the strip in an opposite direction from the third tab and the fourth tab.~~

~~64. The system of claim 63, wherein the first distance is 3 mm.~~

~~65. The system of claim 64, wherein a width of the fifth tab and a width of the sixth tab is 3 mm.~~

~~66. The system of claim 64, wherein the second distance is 10 mm.~~

~~67. The system of claim 56, wherein the electrode assembly is configured to be flexible.~~

~~68. The system of claim 56, wherein the electrodes of the first tab, second tab, third tab, and fourth tab comprise one or both of gold or platinum.~~

~~69. The system of claim 56, wherein the electrode assembly comprises four layers, each layer having a thickness of 5  $\mu\text{m}$ .~~

~~70. The system of claim 56, wherein the current source is configured to provide a substantially constant alternating current of 10 and 100  $\mu\text{A}$  at 20 kHz.~~