of side effects. With the present device, if a device shift occurs, the volume of interest can be re-imaged, and the stimulation volume can be re-directed to the proper region.

[0028] The presently described devices and methods benefit from the ability of modern microfabrication techniques to facilitate the construction of the device. Recent advances in surface micromachining permit various electrode geometries consisting of favorable materials such as Platinum and Platinum-Iridium to be manufactured. The electrode substrates can then be assembled onto cut cylindrical components which consist of the prongs of the device. This assembly is further contained in an implantable catheter from which the prongs would extend during surgery.

[0029] In one embodiment~~aspect~~, an implantable neurological probe is disclosed including: an elongated probe assembly; at least one protruding shafts arranged at the distal end of the elongated probe assembly; a plurality of microelectrode elements arranged on the surface of the protruding shafts; at least one electrical contact arranged proximally along the elongated probe assembly; and at least one electrical conductor in electrical communication between at least one of the microelectrode elements and the at least one electrical contact.

[0030] In some embodiments, the protruding shafts can be reversibly retracted within the elongated probe assembly. In some embodiments, the elongated probe shaft is configured for insertion into a human body using an accepted procedure for insertion of deep brain stimulation leads. In some embodiments, the diameter of the elongated probe assembly is between 1 mm and 3 mm.

[0031] In some embodiments, at least one of the plurality of microelectrode elements is a stimulating electrode and at least one of the plurality of microelectrode elements is a detecting electrode. In some embodiments, at least one of the plurality of microelectrodes elements is both a stimulating electrode and a detecting electrode.

[0032] In some embodiments, each microelectrode element is formed on a conductive film, and where each microelectrode element is embedded within two isolating substrates. In some embodiments, the microelectrode embedded substrate is formable into a cylindrical assembly. In some embodiments, the protruding shafts can be formed to bend radial from the longitudinal axis of the cylindrical assembly. In some embodiments, one of the protruding shafts is longitudinal and centered along the longitudinal axis of the cylindrical assembly. In some embodiments, the protruding shafts are stiffened by a supporting member. In some embodiments, the longitudinal protruding shaft is stiffened by a supporting member.

[0033] Herein disclosed is~~In another aspect,~~ a method for finding a neurological target including: implanting a neurological probe within a vicinity of a neurological target site, the neurological probe including an elongated cylindrical member, a plurality of protruding shafts, a plurality of microelectrode elements on each protruding shaft, at least one electrical contact arranged proximally along the probe shaft, and at least one electrical conductor in electrical communication between at least one of the plurality of the microelectrode elements and the at least one electrical contact; retracting the protruding shafts within the elongated cylindrical member before surgical implantation; expanding the protruding shafts in the vicinity of the neurological target site following implantation; recording electrophysiological signals from the neurological target site using at least one of the microelectrode elements on at least one of the

protruding shafts; and stimulating the neurological target using at least one of the microelectrode elements on at least one of the protruding shafts.

[0034] In some embodiments, the protruding shafts are retracted within the elongated cylindrical member using a flexible pull wire situated in a lumen of the elongated cylindrical member. In some embodiments, the protruding shafts are expanded from within the elongated cylindrical member using a rigid, or semi-rigid, push rod situated in a lumen of the elongated cylindrical member. In some embodiments, the act of positioning the distal end of the neurological probe includes recording neural activity detected by at least one of the plurality of microelectrode elements and repositioning the distal end of the neurological probe as required, until the recorded activity is indicative of the distal end of the elongated probe shaft being located sufficiently at the neurological target site.

[0035] In some embodiments, the act of positioning the distal end of the neurological probe includes stimulating neural activity by applying electrical signals to at least one of the plurality of microelectrode elements on at least one of the plurality of protruding shafts, performing a clinical evaluation of the efficacy on the stimulation site in the implanted patient, and repositioning the distal end of the neurological probe as required, until the patient's response is indicative of the distal end of the elongated probe shaft being located sufficiently at the neurological target site.

[0036] In some embodiments, the act of positioning the distal end of the neurological probe includes inhibiting neural activity by applying electrical signals to at least one of the plurality of microelectrode elements on at least one of the plurality of protruding shafts, performing a clinical evaluation of the efficacy on the inhibition site in the implanted patient, and repositioning the distal end of the neurological probe as required, until the patient's response is indicative of the distal end of the elongated probe shaft being located sufficiently at the neurological target site.

[0037] In another aspect, a method is disclosed for finding a neurological target including: implanting a neurological probe within a vicinity of a neurological target site, the neurological probe including an elongated cylindrical member, a plurality of protruding shafts, a plurality of microelectrode elements on each protruding shaft, at least one electrical contact arranged proximally along the probe shaft, and at least one electrical conductor in electrical communication between at least one of the plurality of the microelectrode elements and the at least one electrical contact; retracting the protruding shafts within the elongated cylindrical member before surgical implantation; expanding the protruding shafts in the vicinity of the neurological target site following implantation; applying an oscillating electric current between at least two of the microelectrode elements on at least one of the protruding shafts; and detecting an electric voltage between at least two of the microelectrode elements on at least one of the protruding shafts.

[0038] In some embodiments, the act of applying oscillating currents and detecting electric voltages is performed to image the electrical characteristics of the volume of neurological tissue between the protruding shafts.

[0039] In oneanother aspect, an implantable neurological probe is disclosed including: an elongated shaft having a distal end and an internal lumen; a support cylinder slidingly disposed in only a distal portion of the internal lumen; a plurality of shafts coupled to the support cylinder and arranged to be selectively extended from the distal end of the elongated shaft; a plurality of microelectrode elements disposed on each of the plurality of shafts, the microelectrode elements formed on a conductive film and including a planar substrate

having ~~an insulative layer and~~ a plurality of conductive traces ~~disposed on the~~embedded within two insulative layer, a stylet
removably disposed in the internal lumen and configured to contact the support cylinder to selectively extend the plurality of shafts during implantation; and a pull wire coupled to the support cylinder to selectively retract the support cylinder and plurality of shafts within the internal lumen.

[0040] Some embodiments include a push-pull rod which includes the pull wire and the stylet.

[0041] In some embodiments, the elongated shaft is configured for insertion into a human body using an accepted procedure for insertion of deep brain stimulation leads.

[0042] In some embodiments, the diameter of the elongated shaft is between 1 mm and 3 mm.

[0043] In some embodiments, at least one of the plurality of microelectrode elements is a stimulating electrode and at least one of the plurality of microelectrode elements is a detecting electrode. In some embodiments, at least one of the plurality of microelectrodes elements is both a stimulating electrode and a detecting electrode.

[0044] As mentioned in the above aspect~~In some embodiments~~, each microelectrode element is formed on a conductive film, and where each microelectrode element is embedded within two isolating substrates.

[0045] As mentioned in the above aspect~~In some embodiments~~, the insulative layers are~~microelectrode embedded substrate is~~ formable into a cylindrical assembly.

[0046] In some embodiments, the protruding shafts can be formed to bend radially from the longitudinal axis of the cylindrical assembly.

[0047] In some embodiments, one of the protruding shafts extends and is centered along the longitudinal axis of the cylindrical assembly.

[0048] In some embodiments, the protruding shafts are stiffened by a supporting member. In some embodiments, the longitudinal protruding shaft is stiffened by a supporting member.

[0049] In another aspect, an implantable neurological probe is disclosed including: an elongated shaft having a distal end and an internal lumen; a plurality of shafts arranged to be selectively extended from the distal end of the elongated shaft; and a plurality of microelectrode elements disposed on each of the plurality of shafts, the microelectrode elements formed on a conductive film and including a planar substrate having~~an insulative layer and~~ a plurality of conductive traces embedded within two~~disposed on the~~ insulative layers. ~~In some embodiments, t~~The plurality of shafts define a~~substantially~~ cylindrical volume when fully extended.

[0050] In some embodiments, the elongated shaft is configured for insertion into a human body using an accepted procedure for insertion of deep brain stimulation leads.

[0051] In some embodiments, the diameter of the elongated shaft is between 1 mm and 3 mm.

[0052] In some embodiments, at least one of the plurality of microelectrode elements is a stimulating electrode and at least one of the plurality of microelectrode elements is a detecting electrode.

[0053] In some embodiments, at least one of the plurality of microelectrodes elements is both a stimulating electrode and a detecting electrode. As mentioned in the above aspect~~In some embodiments~~, each microelectrode element is formed on a conductive film, and where each microelectrode element is embedded within two

isolating substrates. ~~In some embodiments, the microelectrode embedded substrate is~~ and the insulative layers are formable into acylindrical assembly. In some embodiments, the protruding shafts can be formed to bend radially from the longitudinal axis of the cylindrical assembly. In some embodiments, one of the protruding shafts extends and is centered along the longitudinal axis of the cylindrical assembly. In some embodiments, the protruding shafts are stiffened by a supporting member. In some embodiments, the longitudinal protruding shaft is stiffened by a supporting member.

[0054] Also disclosed is~~In another aspect,~~ a method ~~is disclosed~~ for finding a neurological target including: implanting a neurological probe within a vicinity of a neurological target site, the neurological probe including: an elongated shaft having a distal end and an internal lumen; a support cylinder slidingly disposed in only a distal portion of the internal lumen; a plurality of shafts coupled to the support cylinder and arranged to be selectively extended from the distal end of the elongated shaft; a plurality of microelectrode elements disposed on each of the plurality of shafts, the microelectrode elements including a planar substrate having an insulative layer and a plurality of conductive traces disposed on the insulative layer, a stylet removably disposed in the internal lumen and configured to contact the support cylinder to selectively extend the plurality of shafts during implantation; and a pull wire coupled to the support cylinder to selectively retract the support cylinder and plurality of shafts within the internal lumen. In some embodiments, the method further includes: retracting the plurality of shafts within the internal lumen before surgical implantation; extending the plurality of shafts in the vicinity of the neurological target site following implantation; recording electrophysiological signals from the neurological target site using at least one of the microelectrode elements on at least one of the protruding shafts; and stimulating the neurological target using at least one of the microelectrode elements on at least one of the plurality of shafts.

[0055] In some embodiments, the method includes: after the acts of recording and stimulating, retracting the plurality of shafts within the internal lumen and removing the neurological probe from a subject.

[0056] In some embodiments, the protruding shafts are retracted using the pull wire. In some embodiments, the plurality of shafts are extended using the stylet. In some embodiments, the neurological probe includes a push-pull rod which includes the pull wire and the stylet

[0057] In some embodiments, the act of recording neurophysiological signals includes recording neural activity detected by at least one of the plurality of microelectrode elements and repositioning the distal end of the elongated shaft as required, until the recorded activity is indicative of the distal end of the elongated probe shaft being located sufficiently at the neurological target site.

[0058] Some embodiments include stimulating neural activity by applying electrical signals to at least one of the plurality of microelectrode elements on at least one of the plurality of shafts, performing a clinical evaluation of the efficacy on the stimulation site in the implanted patient, and repositioning the distal end of the elongated shaft as required, until the patient's response is indicative of the distal end of the elongated shaft being located sufficiently at the neurological target site.

[0059] Some embodiments include:inhibiting neural activity by applying electrical signals to at least one of the plurality of microelectrode elements on at least one of the plurality of shafts, performing a clinical evaluation of the efficacy on the inhibition site in the implanted patient, and repositioning the

distal end of elongated shaft as required, until the patient's response is indicative of the distal end of the elongated shaft being located sufficiently at the neurological target site.

[0060] There is also disclosed~~In another aspect,~~ a method ~~is disclosed~~ for finding a neurological target including: implanting a neurological probe within a vicinity of a neurological target site, the neurological probe including: an elongated shaft having a distal end and an internal lumen; a support cylinder slidingly disposed in only a distal portion of the internal lumen; a plurality of shafts coupled to the support cylinder and arranged to be selectively extended from the distal end of the elongated shaft; a plurality of microelectrode elements disposed on each of the plurality of shafts, the microelectrode elements including a planar substrate having an insulative layer and a plurality of conductive traces disposed on the insulative layer, a stylet removably disposed in the internal lumen and configured to contact the support cylinder to selectively extend the plurality of shafts during implantation; and a pull wire coupled to the support cylinder to selectively retract the support cylinder and plurality of shafts within the internal lumen. Some embodiments include retracting the plurality of shafts within the internal lumen before surgical implantation; expanding the plurality of shafts in the vicinity of the neurological target site following implantation; applying an oscillating electric current between at least two of the microelectrode elements on at least one of the plurality of shafts; and detecting an electric voltage between at least two of the microelectrode elements on at least one of the plurality of shafts.

[0061] Some embodiments include: after the act of detecting, retracting the plurality of shafts within the internal lumen and removing the neurological probe from a subject.

[0062] Some embodiments include imaging the electrical characteristics of the volume of neurological tissue between the plurality of shafts based on the applied oscillating electric current and the detected electric voltage.

[0063] In some embodiments, the neurological probe includes a push-pull rod which includes the pull wire and the stylet.

[0064] Herein disclosed is~~In another aspect,~~ a method for finding a neurological target including: implanting a neurological probe within a vicinity of a neurological target site, the neurological probe including: an elongated shaft having a distal end and an internal lumen; a plurality of shafts arranged to be selectively extended from the distal end of the elongated shaft; and a plurality of microelectrode elements disposed on each of the plurality of shafts, the microelectrode elements including a planar substrate having an insulative layer and a plurality of conductive traces disposed on the insulative layer, where the plurality of shafts define a substantially cylindrical volume when fully extended. In some embodiments, the method includes: retracting the plurality of shafts within the internal lumen before surgical implantation; extending the plurality of shafts in the vicinity of the neurological target site following implantation; recording electrophysiological signals from the neurological target site using at least one of the microelectrode elements on at least one of the protruding shafts; and stimulating the neurological target using at least one of the microelectrode elements on at least one of the plurality of shafts.

[0065] In some embodiments, the protruding shafts are retracted using a pull wire. In some embodiments, he plurality of shafts are extended using a stylet. In some embodiments, the neurological probe includes a push-pull rod which includes the pull wire and the stylet.

[0066] In some embodiments, the act of recording neurophysiological signals includes recording neural activity detected by at least one of the plurality of microelectrode elements and repositioning the distal end of the elongated shaft as required, until the recorded activity is indicative of the distal end of the elongated probe shaft being located sufficiently at the neurological target site.

[0067] Some embodiments include:after the acts of recording and stimutating, retracting the plurality of shafts within the internal lumen and removing the neurological probe from a subject

[0068] Some embodiments include stimulating neural activity by applying electrical signals to at least one of the plurality of microelectrode elements on at least one of the plurality of shafts; performing a clinical evaluation of the efficacy on the stimulation site in the implanted patient; and repositioning the distal end of the elongated shaft as required, until the patient's response is indicative of the distal end of the elongated shaft being located sufficiently at the neurological target site.

[0069] Some embodiments include inhibiting neural activity by applying electrical signals to at least one of the plurality of microelectrode elements on at least one of the plurality of shafts, performing a clinical evaluation of the efficacy on the inhibition site in the implanted patient, and repositioning the distal end of elongated shaft as required, until the patient's response is indicative of the distal end of the elongated shaft being located sufficiently at the neurological target site.

[0070] Also disclosed is~~In another aspect,~~ a method for finding a neurological target including: implanting a neurological probe within a vicinity of a neurological target site, the neurological probe including: an elongated shaft having a distal end and an internal lumen; a plurality of shafts arranged to be selectively extended from the distal end of the elongated shaft; and a plurality of microelectrode elements disposed on each of the plurality of shafts, the microelectrode elements including a planar substrate having an insulative layer and a plurality of conductive traces disposed on the insulative layer,where the plurality of shafts define a substantially cylindrical volume when fully extended. Some embodiment include retracting the plurality of shafts within the internal lumen before surgical implantation; expanding the plurality of shafts in the vicinity of the neurological target site following implantation; applying an oscillating electric current between at least two of the microelectrode elements on at least one of the plurality of shafts; and detecting an electric voltage between at least two of the microelectrode elements on at least one of the plurality of shafts.

[0071] Some embodiments include imaging the electrical characteristics of the volume of neurological tissue between the plurality of shafts based on the applied oscillating electric current and the detected electric voltage.

[0072] Some embodiments include: after the act of detecting, retracting the plurality of shafts within the internal lumen and removing the neurological probe from a subject.

[0073] Various embodiments may include any of the above described elements or steps alone, or in any suitable combination.

Brief Description of the Drawings

[0074] The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views.