

# INSERTION TOOLS FOR NEURAL STIMULATION, MONITORING, AND MODULATION

## Background

Implantable neurostimulation is undoubtedly the fastest growing application area for implantable electronics in medicine. The implantable neurostimulation market was valued at about \$3.5 billion in 2016 and is expected to grow at a steady pace.

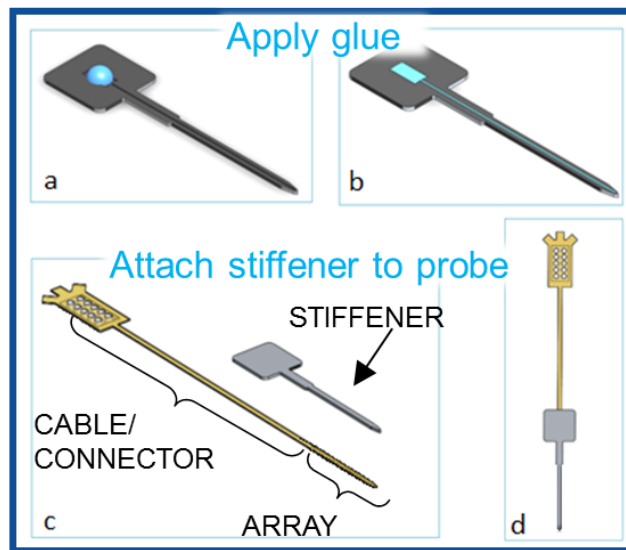
Research involving neural monitoring and modulation offers key insights into the development, prognosis and treatment of disease. Deep brain stimulation is already an approved therapy to treat Parkinson's and essential tremor. A key challenge for researchers remains how to initially insert the multielectrode array, while minimizing the level of damage to the surrounding tissue.

If the probe is rigid, micro movements may cause additional damage and result in glial scarring. If the probe is flexible, its insertion is very difficult.

This portfolio offers a variety of methods for neural probe insertion, each tool with its own set of unique advantages to meet the needs of the type of research being conducted.

## *Adhesive Actuated Insertion Shank*

**IL12469: RIGID STIFFENER-REINFORCED FLEXIBLE NEURAL PROBES, AND METHODS OF FABRICATION USING WICKING CHANNEL-DISTRIBUTED ADHESIVES AND TISSUE INSERTION AND EXTRACTION (US Patent Application [US2014/0378993](#))**



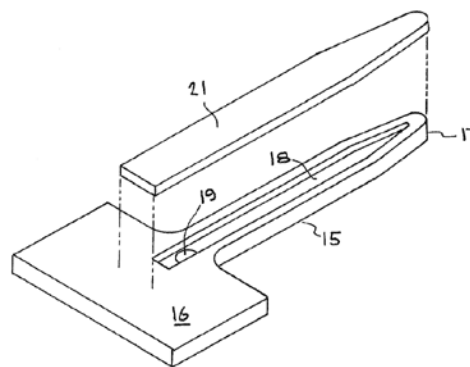
This invention combines a rigid stiffening shank with a flexible body polymer, using a wicking channel and capillary action to distribute the adhesive. Once the probe is inserted, the stiffening shank may be removed, leaving only the flexible polymer body behind.

This invention is superior to silicon based neural probes, as it reduces localized damage induced by post-insertion movements. It is also more useful than purely polymer based probes, which are unable to penetrate neural tissue and therefore require an initial incision in the form of additional surgery, which may result in more glial damage.

Additionally, this stiffening shank apparatus may be easily and efficiently fabricated in large numbers.

### ***Vacuum Actuated Insertion Shank***

**IL12454: VACUUM-ACTUATED PERCUTANEOUS INSERTION/IMPLANTATION TOOL FOR FLEXIBLE NEURAL PROBES AND INTERFACES** (US Patent [9,586,040](#))

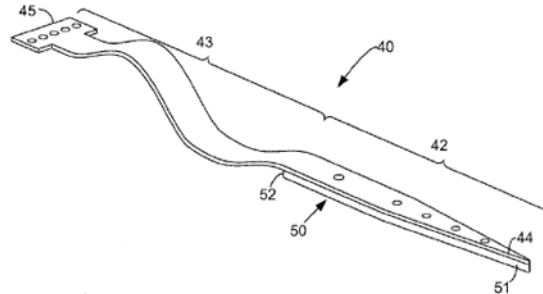


This technology is a flexible device insertion tool including an elongated stiffener (17) with one or more suction ports (19), and a vacuum connector for interfacing the stiffener to a vacuum source. For attaching the flexible device such as a flexible neural probe (21) to the stiffener during insertion by a suction force exerted through the suction ports to, and to release the flexible device by removing the suction force.

The stiffener provides adequate stiffness to the flexible device to enable insertion. This is a faster alternative to a stiffening shank that relies on adhesives, which degrade over time, and may introduce chemicals as other variables to the site of insertion.

## ***Permanently-Bound Rigid Spine Reinforced Polymer Microelectrode Array***

**IL11992: RIGID SPINE REINFORCED POLYMER MICROELECTRODE ARRAY PROBE AND METHOD OF FABRICATION** (US Patent [8,738,110](#) & US Patent Application 14/250298)



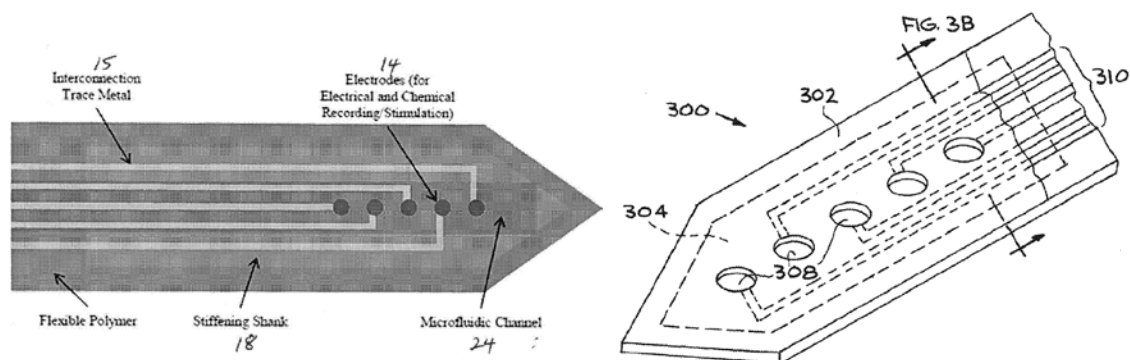
This technology is a flexible elongated probe body with conductive lines enclosed within a polymeric material. The probe also includes a rigid spine (titanium) which enables the typically flexible probe body to penetrate and be inserted into tissue, such as neural tissue, while allowing an integrally connected cable section of the probe body to remain flexible.

The permanent fixture of the rigid component is ideal for experiments where repeated insertion and removal is necessary. This method permits multiple insertions/removals of neural probe without buckling or breaking.

## ***Flexible Microelectrode Array with Embedded Stiffening Shank***

**IL12546: FLEXIBLE MICROELECTRODE ARRAY WITH INTEGRATED STIFFENING SHANK, AND METHOD OF FABRICATION** (US Patent Application [2014/0107446](#))

**IL12651: FLEXIBLE NEURAL INTERFACES WITH INTEGRATED STIFFENING SHANK** (US Patents [9,399,128](#) and [9,788,740](#))

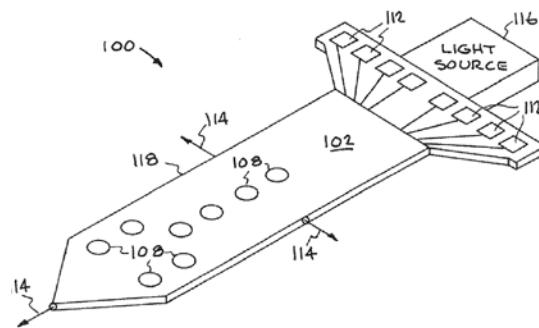


This technology encompasses a stiffener-reinforced microelectrode array device and fabrication method having multiple polymer layers encapsulating one or more electrodes connected to one or more metal traces so that the electrodes are exposed. A stiffening shank is also integrally embedded in the polymer layers adjacent to the insertion end of the device near the electrodes to provide mechanical support during insertion.

Entirely silicon-based probes can corrode over time for long-term implantation uses, whereas chronic probe stiffness can cause glial scarring/injury. This invention offers stiffness for insertion and flexibility for long-term implantation. Additionally, chemical and electrical data may be gathered simultaneously.

### ***Neural Interface with Incorporated Optical Waveguide***

**IL12652: INCORPERATING AN OPTICAL WAVEGUIDE INTO A NEURAL INTERFACE** (US Patent [9,486,641](#))



This technology provides an optical waveguide integrated into a multielectrode array (MEA) neural interface, which includes a device body with an electrode coupled to an electrically conducting lead, and an optical channel with waveguide material in the device body.

The current method to deliver light to light-sensitive cells in the brain and other parts of the nervous system is to use fiber optic waveguides. These fibers are commercially available and can be made as small as 50  $\mu\text{m}$  in diameter, however they are not ideal. At 50-200  $\mu\text{m}$  in diameter, the fibers are still too large to implant and study many important regions of the brain. Each fiber provides only one point of light source and one wavelength. There is a need for a light delivery system that is able to deliver multiple wavelengths as needed and in multiple areas, all with a minimal device footprint. Optical fibers also have low light delivery efficiency. Often a 100 mW source is required to deliver 1-5 mW to the desired site. The fiber optics is implanted separately and relatively far from the signal recording device. There is a need for a system wherein the recording electrodes are placed within microns of the delivered light source and the stimulated cells.

This invention addresses the unmet need for targeted neural stimulation, which is achieved by delivering multiple wavelengths to multiple neural areas with minimal device footprint.

## **Potential Applications**

These neural probe insertion tools offer superior insertion methods for neuro-therapeutic devices used in brain-computer interfaces (BCIs). BCIs use implanted neural probes to bypass damaged tissue and stimulate neural activity, so that a patient can regain lost communication and/or control with respect to some aspect of the patient's nervous system.

These innovations may find additional applications in neuroscience research to understand the neuronal activity of neurons, neurological diseases, neural coding, neural modulations, and neural topologies.

## **Development Status**

LLNL is seeking industry partners with a demonstrated ability to bring such inventions to the market. Moving critical technology beyond the Laboratory to the commercial world helps our licensees gain a competitive edge in the marketplace. All licensing activities are conducted under policies relating to the strict nondisclosure of company proprietary information.

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