(SD2021-057) Electro-optical mechanically flexible neural probes

Tech ID: 32897 / UC Case 2021-Z08-1

BACKGROUND

Microelectrodes are the gold standard for measuring the activity of individual neurons at high temporal resolution in any nervous system region and central to defining the role of neural circuits in controlling behavior. Microelectrode technologies such as the Utah or Michigan arrays, have allowed tracking of distributed neural activity with millisecond precision. However, their large footprint and rigidity lead to tissue damage and inflammation that hamper long-term recordings. State of the art Neuropixel and carbon fiber probes have improved on these previous devices by increasing electrode density and reducing probe dimensions and rigidity. Although these probes have advanced the field of recordings, next-generation devices should enable targeted stimulation in addition to colocalized electrical recordings. Optogenetic techniques enable high-speed modulation of cellular activity through targeted expression and activation of light-sensitive opsins. However, given the strong light scattering and high absorption properties of neural tissue optogenetic interfacing with deep neural circuits typically requires the implantation of large-diameter rigid fibers, which can make this approach more invasive than its electrical counterpart.

Approaches to integrating optical and electrical modalities have ranged from adding fiber optics to existing Utah arrays to the Optetrode or other integrated electro-optical coaxial structures. These technologies have shown great promise for simultaneous electrical recordings and optical stimulation in vivo. However, the need to reduce the device footprint to minimize immune responses for long-term recordings is still present.

TECHNOLOGY DESCRIPTION

Researchers from UC San Diego and the Salk collaboratively developed a microcoaxial neural probe design that has a low electrical impedance channel in close proximity to a low loss optical channel. The probes can be fabricated as small as 8 µm and lengths up to several millimeters using microfiber optic waveguide cores or even smaller diameters with nanofiber optic cores. The small size and mechanical flexibility allows the probes to be implanted with minimal immune responses.

This invention works by utilizing a low impedance electrical channel surrounding a small central fiber optic core that can than be directly inserted into neural tissue. The fiber optic cores can be bonded directly to single-mode fibers (SMFs) to create detachable, low-loss optical interfaces that can be directly connected to

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OTHER INFORMATION

CATEGORIZED AS

- **Medical**
  - Disease: Central Nervous System
  - Research Tools
- **Sensors & Instrumentation**
  - Medical

RELATED CASES

2021-Z08-1

standard optogenetic hardware. The platform also allows straightforward fabrication routes to high-density arrays for long-term interfacing with minimal disturbance to the surrounding neural tissue.

APPLICATIONS

Neural interfacing, medical diagnostics, diseases treatment, neural research, human-machine interfaces.

ADVANTAGES

A multi-modal coaxial microprobe design with a minimally invasive footprint (8-14 μm diameter over millimeter lengths) that enables efficient electrical and optical interrogation of neural networks. In the brain, the probes allowed robust electrical measurement and optogenetic stimulation. Scalable fabrication strategies can be used with various electrical and optical materials, making the probes highly customizable to experimental requirements, including length, diameter, and mechanical properties. Given their negligible inflammatory response, these probes promise to enable a new generation of readily tunable multi-modal devices for long-term, minimally invasive interfacing with neural circuits.

STATE OF DEVELOPMENT

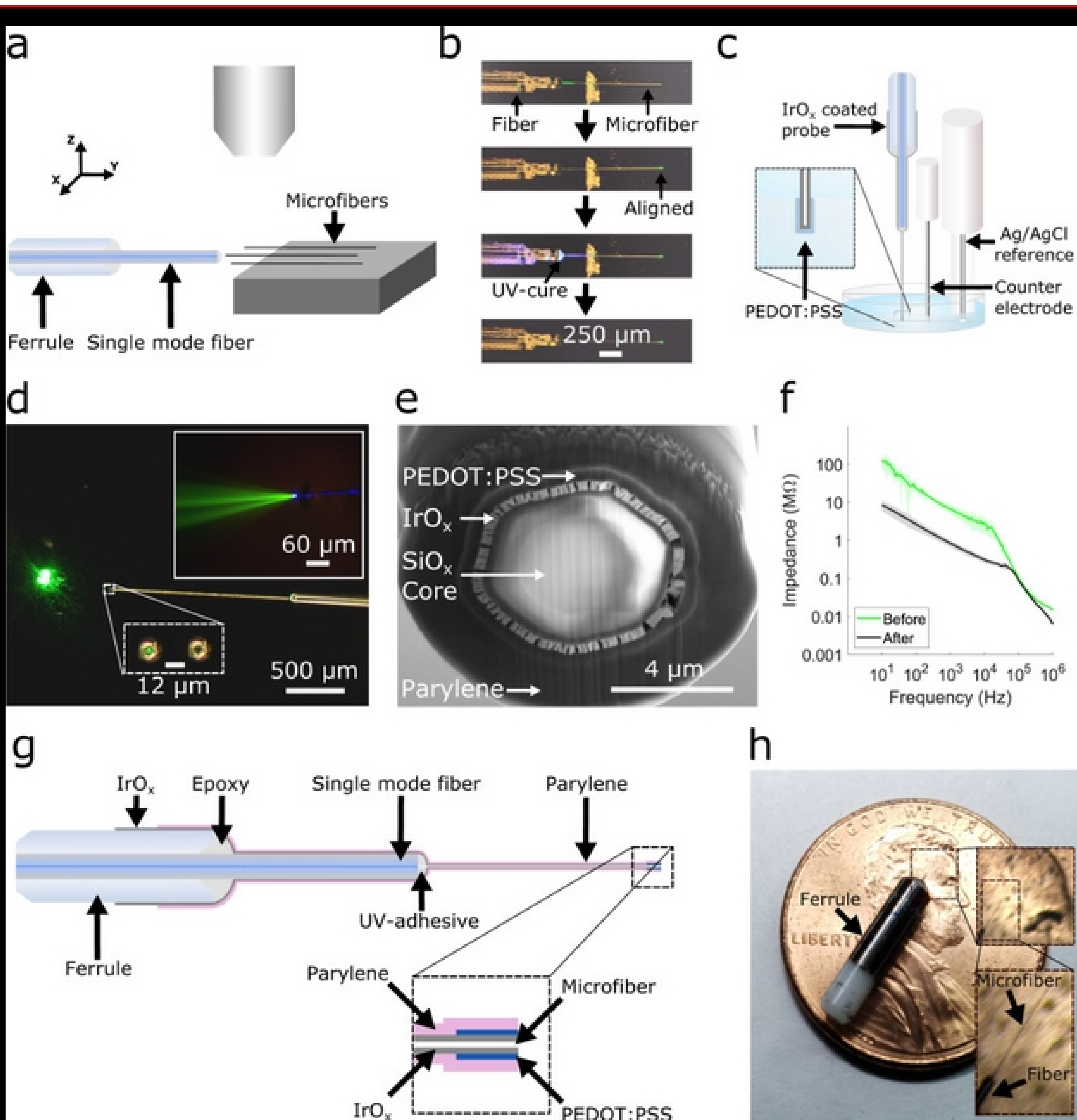

Fig. 1. Fabrication of implantable EO-Flex probes along with optical and electrical characterization. **a** Silica microfibers of defined length are positioned on a silicon substrate to allow a single-mode fiber (SMF)-loaded ferrule to bond to the microfiber. **b** (from top to

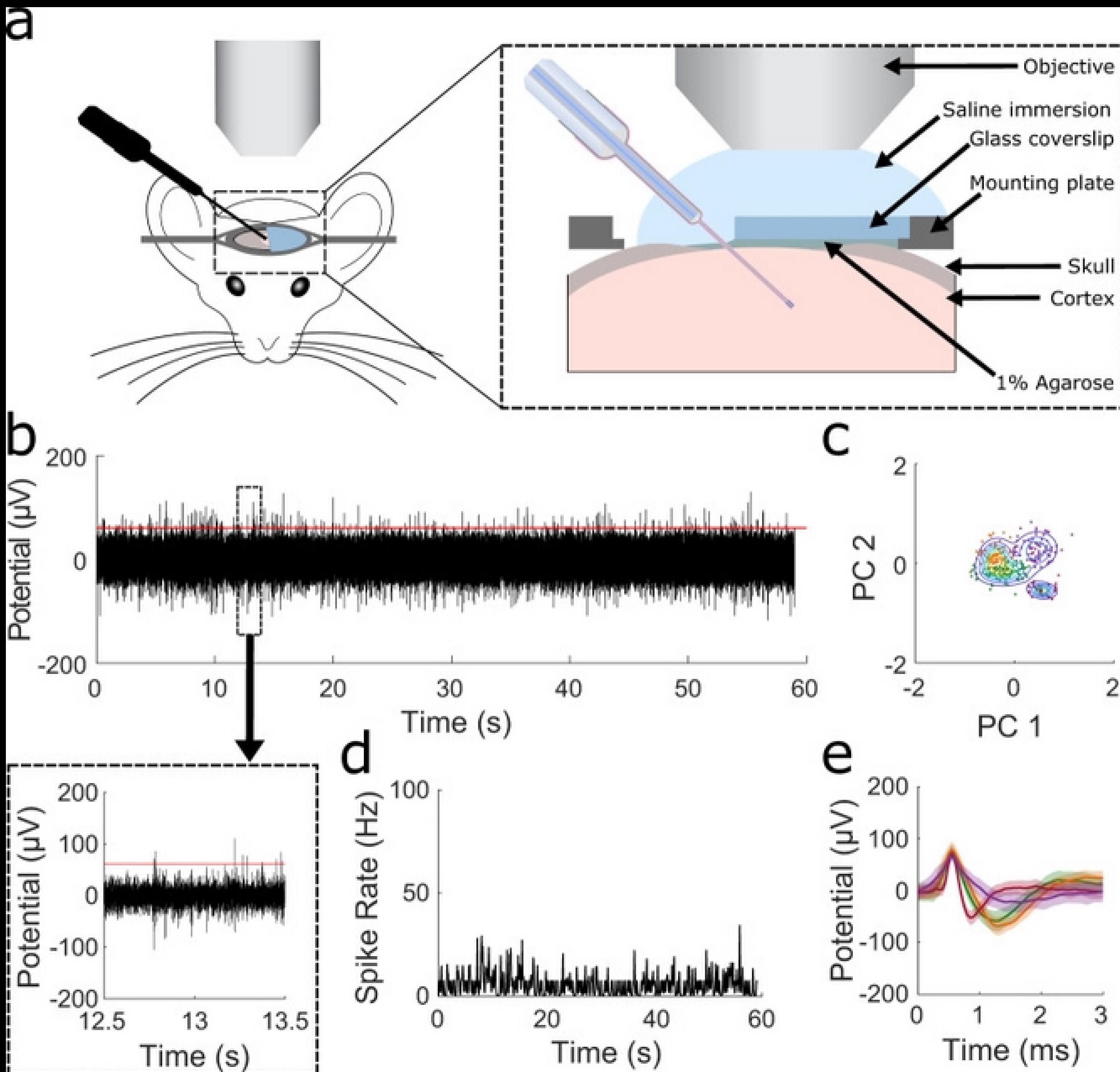

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Fig. 2. Extracellular neural recordings in the cortex of live mice using the EO-Flex probes.
a Schematic showing the setup used for visually guided electrical measurements. Two-photon imaging of the probe in relation to fluorescently labeled cells (see Methods) was used to track its movement through tissue and optimize the recording position. (inset) Zoom-in cross

INTELLECTUAL PROPERTY INFO

This patent-pending technology is available for licensing.

The invention allows for high resolution electrical and optical interfacing with deep intrinsic neural circuits.

The in vivo data demonstrate the ability of EO-Flex probes to electrically record and optically modulate neural activity in the intact brain.

RELATED MATERIALS

▶ Ward S, Riley C, Carey EM, Nguyen J, Esener S, Nimmerjahn A, Sirbuly DJ. Electro-optical mechanically flexible coaxial microprobes for minimally invasive interfacing with intrinsic neural circuits. Nat Commun. 2022 Jun 7;13(1):3286. doi: 10.1038/s41467-022-30275-x. PMID: 35672294; PMCID: PMC9174211. - 06/07/2022

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