

# An Implantable Upconversion Microdevice Controlling Brain Activity in Behaving Animals

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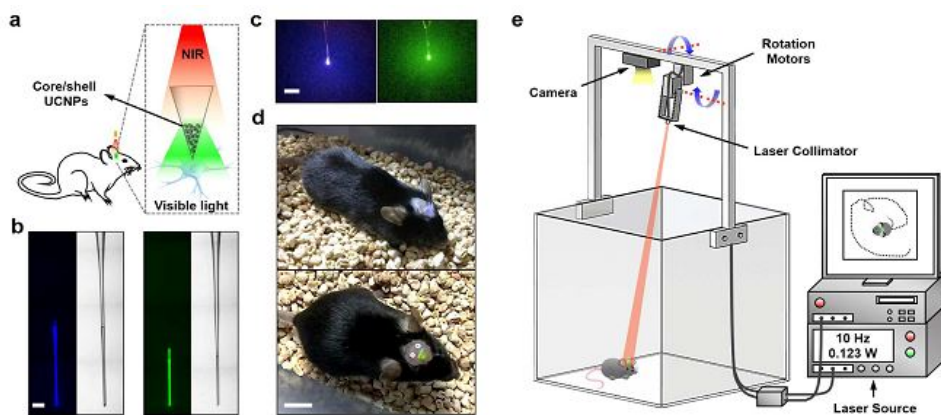


Figure 1. Upconversion-based neural stimulation technique.

- (a) Schematic of tetherless nearinfrared (NIR) optogenetic control of brain activity using fully implantable upconversion microdevices.
- (b) Bright-field and fluorescent photographs of the implantable micro-optrodes
- (c) Fluorescent images of the operating UCNP micro-devices
- (d) Images of animals implanted with different types of micro-optrodes.
- (e) Instrumentation design of a robotic laser projection system for automatic and consistent NIR irradiation of the heads of behaving animals.

## Opportunity

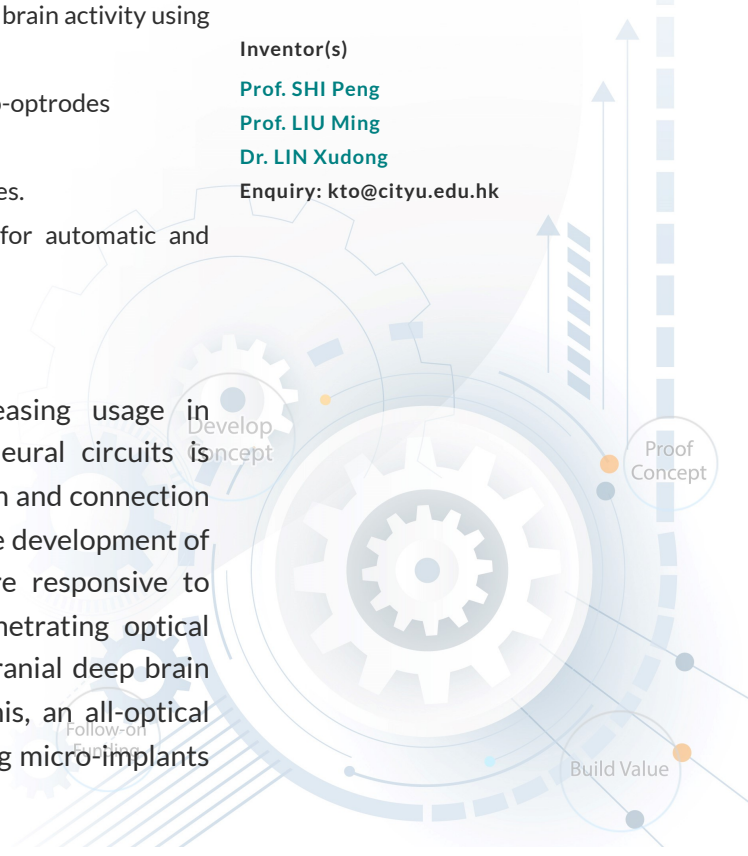
Optogenetic techniques and devices are finding increasing usage in neuroscience. For instance, the optical modulation of neural circuits is becoming an effective technique for elucidating the function and connection of the nervous system. However, despite the progress in the development of different variants of light sensitive ion channels that are responsive to various light wavelengths, remote delivery of tissue penetrating optical signals, such as deep red or near-infrared light, for transcranial deep brain stimulation is yet to be realised. Therefore, to achieve this, an all-optical system for tetherless remote control of neural activity using micro-implants based on upconversion technology is developed.

**IP Status**  
Patent granted

Technology Readiness Level (TRL) ?

5

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## Technology

In this all-optical system of fully implantable micro-devices for tetherless remote control of neural activity, transducers made of upconversion nanoparticles (UCNPs) are used to convert near-infrared (NIR) energy to visible light to stimulate neurons expressing different opsin proteins. UCNPs are packaged in a glass micro-optrode to form an implantable device with superb long-term biocompatibility. It is shown that remotely applied NIR illumination is able to reliably trigger spiking activity in rat brains. Together with a robotic laser projection system, the upconversion-based tetherless neural stimulation technique is implemented to modulate brain activity in the striatum, ventral tegmental area, and visual cortex regions of brain. Thus, this system can achieve behavioural conditioning in freely moving animals.

## Advantages

- Unlike existing technology, this new all-optical system for controlling neural activity is tetherless.
- The implant is smaller and lighter than any existing products in the market.
- The robotic projection system used is easier to manage and cheaper than any existing system.

## Applications

- This invention offers fully implantable upconversion devices for tetherless near-infrared control of neural activity in behaving animals.
- These implants would be useful for both basic and translational neuroscience research.

