Docket #: S14-453

A wirelessly powered, fully internal implant that enables optogenetic stimulation of brain, spinal cord, and peripheral nervous system in untethered mice

Stanford researchers have developed a wirelessly powered, fully internal implant which allows for optogenetic control of neurons throughout the nervous system in mammals, and in particular, mice. The smallest version of this implant (20 mg, 10 mm^3) is two orders of magnitude smaller than other wireless optogenetic systems, which allows it to be fully implanted beneath the skin anywhere in the body to target multiple neural structures, both deep and superficial. This system enables optogenetic experiments in which animals are able to behave naturally with optogenetic manipulation of both central and peripheral targets.

Stanford News Article– "Miniature wireless device being developed by Stanford Bio-X team creates better way of studying chronic pain", 10/7/14

Video of freely moving mice with wireless implants

Stage of Research

- **Proof-of-principle** demonstrated in awake and freely moving mice -

see video above

- Developed a method to improve power variability to within 10%, by measuring reflected power at the resonant cavity ports
- Demonstrated how three adaptations of the implant allow for untethered optogenetic control throughout the nervous system (brain, spinal cord, and periphery)

- Implanted the stimulator directly at the sciatic nerve to study the pain response of AAV6-ChR2 injected mice
- This system can be further applied to study social behavior of mice because multiple devices can be controlled at once and the totally internal implants have little to no influence on social interactions between mice

Applications

- **Neuroscience Research** - optogenetic control of neural circuits in mice, rats, and other mammals for neuroscience investigations

Advantages

- **Small size of implant** - smallest version is 20 mg, 10 mm^3 which is much smaller than other wireless optogenetic systems,
- **Fully implantable beneath the skin**
- **Non-tethered wireless system** allows for freely moving animals
- **Improvements on wireless optogenetic light delivery**
- **Allows for optogenetic control of neurons outside of the brain**
- **Allows for optogenetic control of neurons deep within the body**
- **Low cost**
- **Easy-to-build**
- **Easily adapted for many neural targets**
- **Adaptable for other functionalities** – (e.g. simultaneous recording, multiple LEDs)
- **Targets large market - $600B/year**

Publications

- J. S. Ho, Y. Tanabe, S. M. Iyer, A. J. Christensen, L. Grosenick, K. Deisseroth, S. L. Delp, and A. S. Y. Poon, "Self-tracking energy transfer for neural stimulation in untethered mice," arXiv:1503.01493
- A. J. Yeh, K. L. Montgomery, J. S. Ho, V. Tsao, E. A. Ferenczi, S. M. Iyer, L. M. Grosenick, Y. Tanabe, K. Deisseroth, S. L. Delp, and A. S. Y. Poon, "Fully internal wireless optogenetics for truly untethered stimulation," Annual Meeting of the Society for Neuroscience (SFN), Washington, DC, Nov. 2014.

Patents

- Published Application: WO2015171213
- Published Application: 20170065828
- Issued: 10,434,329 (USA)

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