Single 5 μm diameter multifunctional neuroprobe block module devices

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Introduction: In advance neuroscience, optogenetics offers an enormous potential for the future especially to study about brain. Through this method, excitation and silencing of cells can be simply performed by light with high precision in a reversible manner. In the previous research done by our group, we had overcome the limitations of conventional waveguide devices for optogenetics through the fabrication of the three-dimensional platinum/silicon dioxide microtube arrays that consists of both optical stimulating micro-scale light source and electrical recording site in the same alignment [1, 2]. However, the size of the device (8×8 mm^2) substrate is relatively large to approach various cortical areas as *in vivo* is a priority, particularly when it comes to test on animals (e.g., rodents). To achieve the miniaturization of the device, here we fabricate a single microtube with a 5 μm diameter on a 1×1 mm^2 block module (Fig. 1a). In addition, the microtube block module can be assembled into numerous device packages.

Experiment and result: The device process is based on vapor-liquid-solid (VLS) growth of silicon-microwire on a 1×1 mm^2 block of conductive silicon and subsequent three-dimensional fabrication processes. A catalytic-Au is placed by evaporation and lift-off. With the Au catalysts, vertical silicon-microwires are formed by VLS growth of silicon (Fig 1c). Then, a platinum is deposited over the core silicon-wire by sputtering, forming the clad and the metal interconnection. This is followed by parylene depositions. After exposing the tip section of parylene/metal, the core silicon-wire is etched away with XeF_2 for the microtube completion [1, 2]. Finally, laser dicing is used to separate each section of the microtube block module. LEDs (350 μm × 350 μm, peak wavelength of 403 nm) can be assembled on the printed circuit board (PCB), which consists of <300-μm-diameter of holes for the LED illumination (Fig 2). The PCB also consists of wire bonding pads for the electrical connation with the LED. Optical transmission through the microtube was demonstrated using the PCB mounted LED. The optical signal through the aligned the PCB-hole and the microtube is observed using a camera (Fig.3). Although we discussed the preliminary results, the optical stimulation of neurons with a high spatial resolution and numerous device assembly (single or multi-channel) would be possible via the single 5 μm diameter multifunctional neuroprobe block module devices.

1. M. Sakata et al., *Appl. Phys. Lett.* **104**, 164101, 2014.
2. T. Matsuo et al., 75th JSAP Autumn Meeting, 2014.

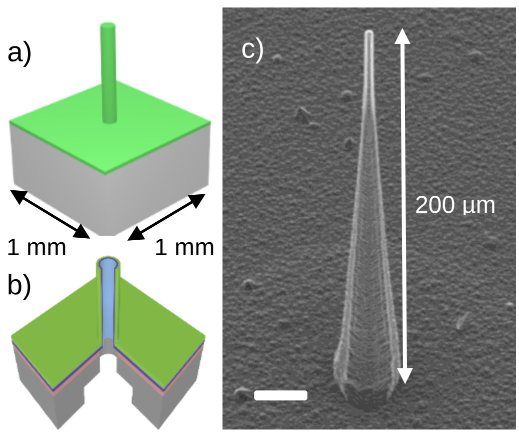

Fig. 1: Optical neuroprobe block module device. a) Illustration of the device, b) device's cross-section, and c) SEM image of fabricated microprobe.

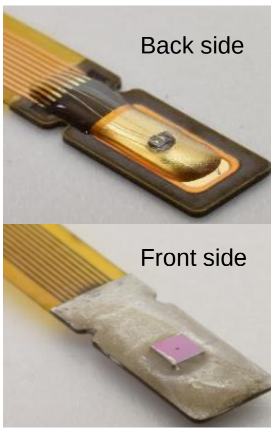

Fig. 2: LED and device on PCB.

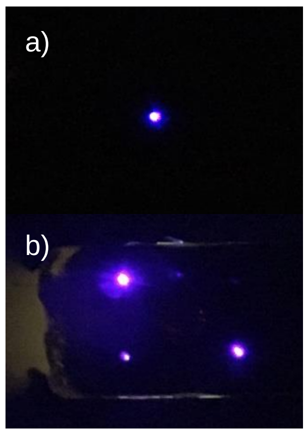

Fig. 3: Optical transmission through the microtube using the PCB mounted LEDs.