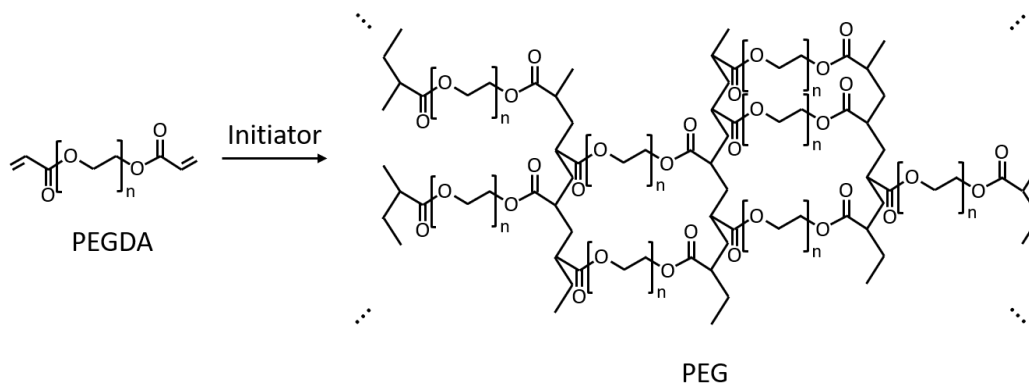


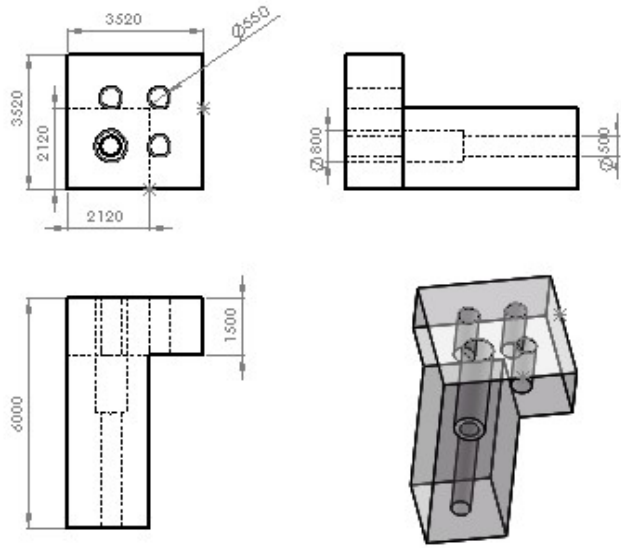
## Supporting Information

### Neural interfaces by hydrogels

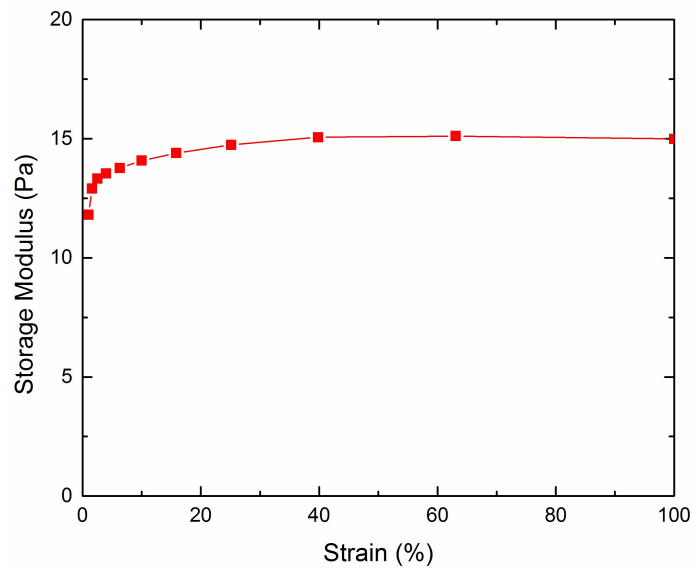
Hao Sheng, Xiaomeng Wang, Ning Kong, Wang Xi, Hang Yang, Xiaotong Wu, Kangling Wu, Chenghai Li, Jian Hu, Jingda Tang, Jinxiong Zhou, Shumin Duan, Hao Wang\*, Zhigang Suo\*



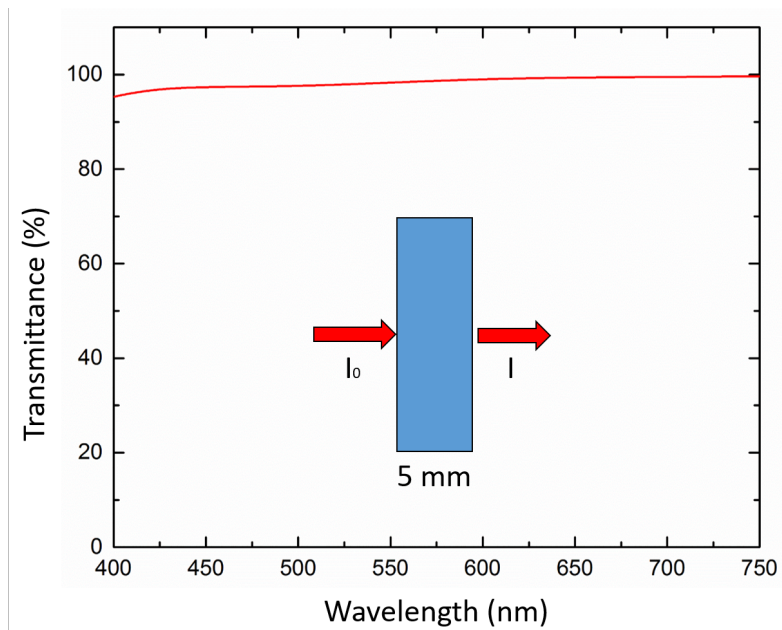
**Figure S1.** The synthesis of the polyethylene glycol (PEG) hydrogel. Each polymer chain of polyethylene glycol diacrylate (PEGDA) has carbon-carbon double bonds at both ends. In the presence of an initiator, the double bonds open and connect with the opening double bonds on other chains, and the chains form a network.



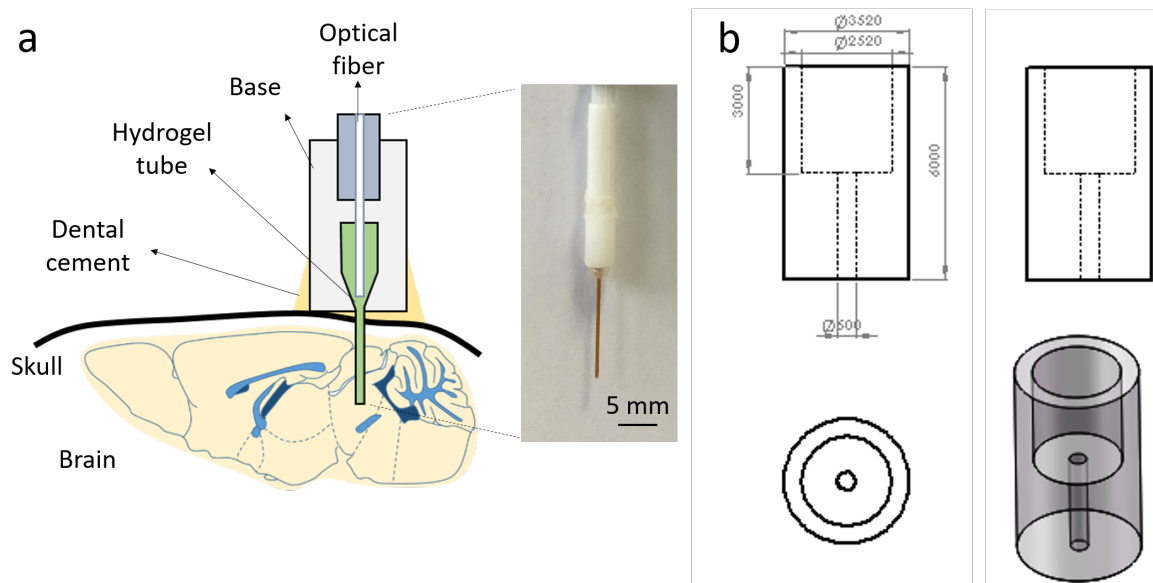
**Figure S2.** The base of the hydrogel interface for recording local field potentials in free-moving mice. The long hole is used as the signal channel, and the three other short holes are used as the ground channels. The base was fabricated with 3D resinous material (Stratasys Verowhite Plus) using a 3D printer (Stratasys Objet350 Connex3). The unit in this figure is millimeter.



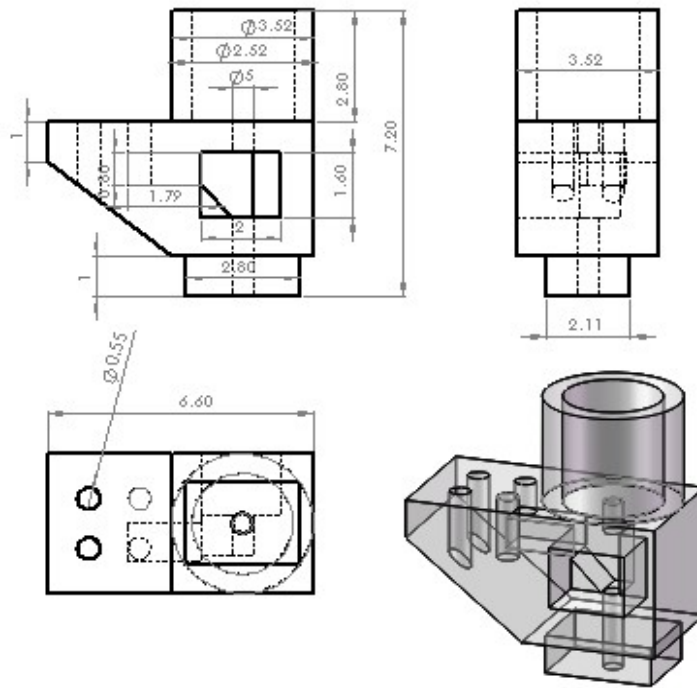
**Figure S3.** The modulus of the PEG-ACSF hydrogel. The storage modulus (shear modulus) of the PEG-ACSF hydrogel was measured by a rheometer (Anton Paar, MCR 302). Since the hydrogel is an incompressible material, its young's modulus is three times of its storage modulus, around 45 Pa.



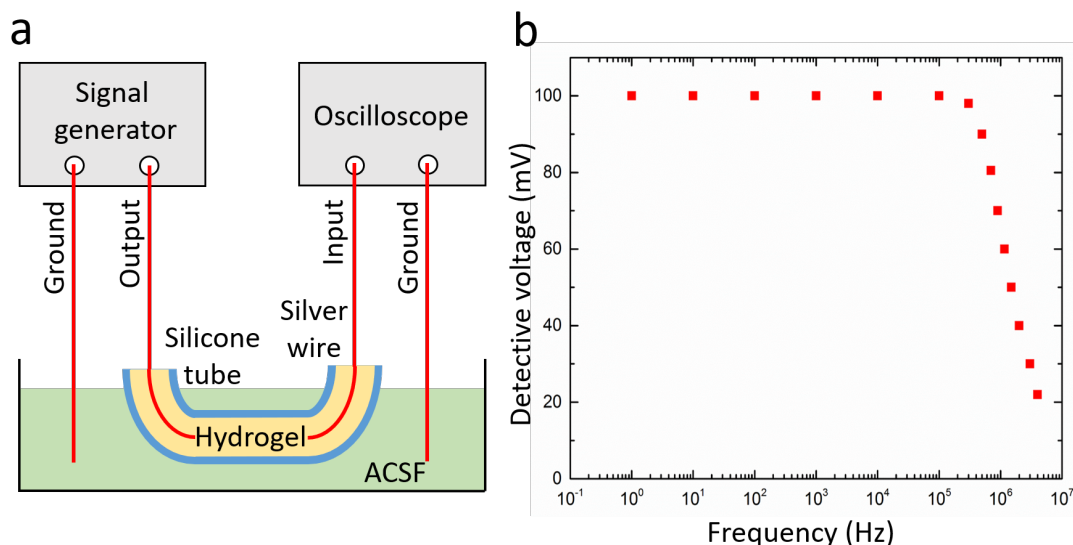
**Figure S4.** The transmittance of the PEG-ACSF hydrogel. The transmittance of the PEG-ACSF hydrogels was measured by a spectrometer (PerkinElmer Lambda 950). A 5mm-thick PEG-ACSF hydrogel shows an average transmittance ( $I/I_0$ ) of 98.4 % in the visible range. The thickness of the brain of a mouse is about 5 mm, representing the longest optical path needed in optogenetics.



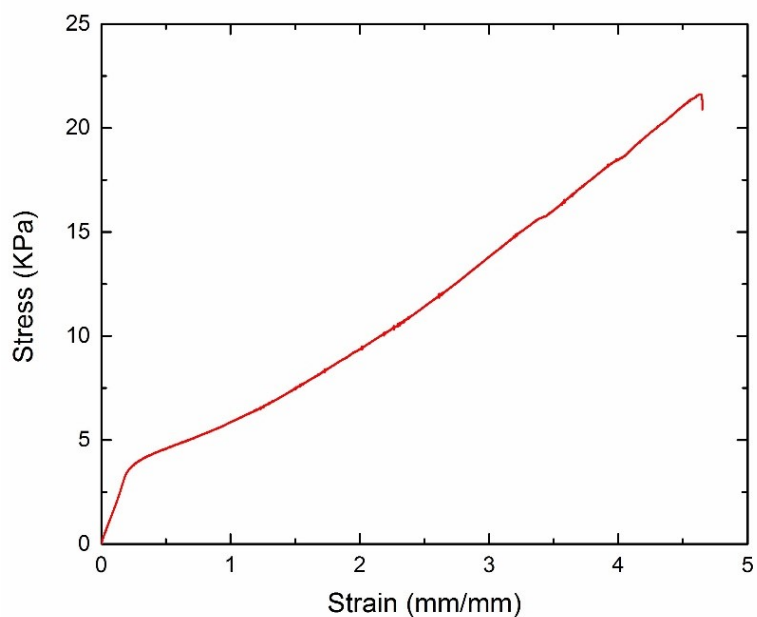
**Figure S5.** The design of the hydrogel interface for laser stimulation. a) Schematic of the experimental setup, and a photo of the cap. b) The drawing of the base. The cavity is the receptor of the optical fiber. The base was fabricated with 3D resinous material (Stratasys Verowhite Plus) using a 3D printer (Stratasys Objet350 Connex3). The unit in figure b is millimeter.



**Figure S6.** The base of the hydrogel interface for simultaneous laser stimulation and electrical recording. The lateral platform for electrical recording is designed as in Figure S2. The top cavity is the receptor for the optical fiber. The base was fabricated with 3D resinous material (Stratasys Verowhite Plus) using a 3D printer (Stratasys Objet350 Connex3). The unit in this figure is millimeter.



**Figure S7.** The detective range of hydrogel interfaces. a) We first prepared the PEG-ACSF hydrogel in a 1cm-long (scale of mice brains), 1mm inner diameter (scale of the diameter of our hydrogel interfaces) 1.5 mm outer diameter silicone tube. Then we connected the output of a signal generator (RIGOL, DG4062) with the input of an oscilloscope (Agilent Technologies, DSO-X 3012A) through the hydrogel-silicone tube, and connected their grounds. After that, we used the generator to output sinusoidal waves of  $\pm 100$  mV (scale of the polarization voltage of neurons) of different frequencies and checked detective waves on the oscilloscope. In this experiment, the generator stimulated the brain, the hydrogel-silicone tube stimulated the hydrogel interface, and the oscilloscope stimulated the detector. b) The detected voltages at different frequencies. Signals remain undistorted when the frequency is below 100 kHz. By comparison, signal frequencies of neurons are less than 1 kHz.



**Figure S8.** The modulus of the silicone tube used in frozen hydrogel. The stress-strain curve was detected by a stretch machine (SHIMADZU AGS-X, sensor range 50 N). We chose the curve beneath the stress of 3 kPa to calculate the modulus.