

A wireless optogenetic stimulation system for long-term function evaluation of mice forelimb with sub-nerve resolution

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Supplementary Methods

1. Pre-curling of the FIMOSS MOSD II

In the sacrificial pre-curling process, copper jump wire ($d=0.01\text{mm}$) was used to “suture” the flat cuff FPC into a cuff by threading the wire across the two outer ipsilateral eyelets (Supplementary Fig.4a,b). A second identical knot was made on the other pair of outer eyelets to reinforce the cuff formation. A side view of the sutured cuff was shown in Supplementary Fig.4c. The devices then underwent plasma treatment. And a thin layer ($\sim 150\mu\text{m}$ thick) of PDMS mixture (A:B=12:1, Sylgard 184, Dow Corning) was applied to the cuff and the interconnect FPC, and cured at 85°C for 30 minutes (Supplementary Fig.4d). Once the device was cooled to room temperature, a pair of ophthalmic scissors was used to cut off the knots together with the outer eyelets (Supplementary Fig.4e,f). Lastly, PDMS mixture was applied to the site of the cut, and cured at 85°C for 30 minutes. The device was now fully encapsulated, and ready to be used for implantation.

2. Characterization of power consumption and wireless power transfer capability of FIMOSS implant

To measure the power consumption of FIMOSS implant during a typical stimulation event, the implant was connected to a custom-built current meter in series (Supplementary Fig.14 upper left). The implant’s current consumption was measured by the current meter when powered by a constant voltage source at 3V. The current meter was composed of a $200\text{m}\Omega$ sensing resistor, whose voltage signal was amplified by an operational amplifier circuit (gain=834 folds), and recorded. The current through the sensing resistor (which is also the current of the test subject connected in series) can thus be calculated via ohm’s law. The current meter was calibrated by measuring current through standard resistance (500Ω , $1\text{k}\Omega$, $2\text{k}\Omega$, $5\text{k}\Omega$ and $10\text{k}\Omega$).

To characterize the WPT capability of FIMOSS system, an adjustable load (a potentiometer) was connected to the FIMOSS implant’s power pins (VCC and GND). The implant was wirelessly powered by an external device under the default wireless condition (external device set at 3.3V, 60~80mA; the emitting antenna and receiver antenna were concentrically aligned, in parallel and 1mm apart). The voltage and the current of the adjustable load were measured by an oscilloscope (MDO34, Tektronix) and the custom-built current meter respectively, while the adjustable load performed a load sweep from $40\text{k}\Omega$ to 0Ω (Supplementary Fig.14 upper right).

3. Light-current-voltage (LIV) characterization of the μLED

To measure the luminous intensity (L), current (I) and voltage (V) of the bare μLED without PDMS encapsulation, the μLED was connected to the custom-built current meter and a variable resistor in series and powered with a constant voltage source at 3V (Supplementary Fig.14 bottom right). An amplified photodetector (PDA100A, ThorLabs) was placed $\sim 2\text{mm}$ over the μLED in a dark environment. The photodetector, current meter and an oscilloscope (MDO34, Tektronix) measured the L, I and V of the μLED simultaneously while the variable resistor performed a load sweep from 0mA to 10mA. The luminous intensity measurements from the photodetector were relative, and were normalized to the μLED ’s rated optical power of 6.5mW at 5mA of current.

4. Temperature measurement of the implant in vivo and in vitro

In the temperature change test *in vitro*, all FIMOSS implants were placed with the MCU downside on a 1mm-thick glass slide, and the external antennas were fixed underneath the slide. Then, the receiving antennas of implants and the external antennas were vertically aligned. The ambient temperature was adjusted to 26°C . And voltages of the DC power supply were adjusted to 3.3V, 3.6V, 3.9V, and 4.2V to power the external device, thus wirelessly driving the FIMOSS implants. The stimulation parameters of the FIMOSS implants were adjusted to 20ms pulse width and 1000ms inter-pulse interval, with the 4 μLED s lighting sequentially. For short-term

in vitro temperature change test, we measured the maximum temperature of implants every 20s at different voltages during the first 200s. For long-term temperature change test, we recorded the temperature of implants every 300s during the of 7200s' continuous operation.

In the temperature change test *in vivo*, the FIMOSS implant in the right thoracic subcutaneous tissue of a Thy1-ChR2-EYFP male mouse were wirelessly powered by an external device (set at 3.3V, 60~80mA). The stimulation parameters of FIMOSS implants, ambient temperature, and temperature measurement method were consistent with the *in vitro* temperature change test. The driver and coil of the FIMOSS *in vivo* machine were implanted into the right thoracic subcutaneous tissue of the mouse, and the MOSD II was implanted into the brachial plexus of the mouse. The surgical procedures of implantation were the same, and the tests were performed 2 weeks after implantation when the incisions had fully healed. Before detection, the right thoracic hair of the mouse was completely removed. The temperature change test *in vivo* lasted for 3600s, and the maximum temperature of the right thoracic wall was measured every 900s.

Optris Infrared Thermometers were used for temperature measurement. Throughout the process, we kept the detection distance and detection parameters of the infrared thermometer consistent. Finally, we imported the temperature measurement photographs taken by the infrared thermometer into the computer and tabulated the implant's temperatures at different time points into excel for statistical analysis.

5. Temperature measurement of μ LED in vivo

A FIMOSS implant's μ LED cuff was sutured tightly onto a thermistor (GAG22K7MCD419, TE connectivity measurement specialties), mimicking the standard use case of cuffing a target nerve. The μ LED cuff with the thermistor was inserted into the subcutaneous space of a mouse under general anesthesia (GA). The temperature of the μ LED was measured by monitoring the temperature-dependent resistance of the thermistor. The resistance of the thermistor was recorded by a custom-built acquisition circuit (Supplementary Fig.14 bottom left). The temperature recording started when the reading stabilized at the mouse' body temperature under GA (~36°C). Then one μ LED was activated and maintained constant illumination at 2.1mA for 20 seconds, throughout which temperature was constantly recorded.

6. Accelerated aging test in vitro

The FIMOSS implants were required to continuously operate for more than 12 weeks after implantation in the brachial plexus of mice. Therefore, prior to surgery, accelerated aging test was conducted *in vitro* using 10 FIMOSS implants to predict their expected *in vivo* lifetime (Supplementary Fig.3). 5 of the implants were encapsulated only with a layer of 12 μ m Parylene C coating (Supplementary Fig.3a), and the other 5 were protected with standard encapsulation consisting of 12 μ m Parylene C and 500 μ m PDMS (Supplementary Fig.3b).

In the accelerating aging test, we immersed the FIMOSS implants in a saline solution at 60°C (24 hours/day, 7 days/week) and wirelessly powered them on for 30 minutes per day under immersion conditions until the device failed. The date on which any of the μ LEDs failed to illuminate was recorded as the termination date of the effective operation of the device; normal function of the device was indicated by all μ LEDs illuminating as programmed, and the status LED on the driver illuminating as programmed.

$$\frac{k_1}{k_2} = 2^{(T_1 - T_2)/10} \text{ (Equation 7)}$$

T represents temperature in Kelvin. k_1/k_2 is the acceleration factor of the elevated test temperature (T_1) relative to body temperature (T_2).

7. Time accuracy test for the μ LEDs in FIMOSS implants

The FIMOSS implants were programmed with 6 different parameters: 10ms pulse width /1000ms inter-pulse interval, 20ms pulse width/1000ms inter-pulse interval, 30ms pulse width/1000ms inter-pulse interval, 40ms pulse width/1000ms inter-pulse interval, 50ms pulse width/1000ms inter-pulse interval, 200ms pulse width/2000ms inter-pulse interval. And 4

μ LEDs were activated in sequence. A photodetector (PDA100A-EC Si Amplified Detector, Thorlabs, USA) was employed to detect the optical signals at the MOSD II, with the sensitivity adjusted to 100,000 Hz. The detected signal curve exhibited a continuous square wave pattern, indicating the illumination of μ LEDs.

The time accuracy of the μ LEDs was determined by identifying the points where the square wave began to rise and returned to baseline, which corresponded to the start and end of the μ LED illumination respectively. The duration of each μ LED's illumination and the interval between consecutive activations were calculated as pulse width and inter-pulse interval.

For the first 5 lighting parameters, the experiment lasted approximately 2 minutes, encompassing 25 cycles of μ LED illumination. The illumination durations and intervals for all 4 μ LEDs within each cycle were included in the statistical analysis. For the 6th parameter, data from 13 cycles over approximately two minutes were similarly analyzed.

Using a Python script, we computed the illumination durations for each μ LED and the intervals between activations. The deviation rate is calculated based on the realistic measured time ($t_{\text{realistic}}$) of illumination or interval and the setting time (t_{setting}). was calculated using the following formula:

$$\text{Deviation rate} = \frac{(t_{\text{realistic}} - t_{\text{setting}})}{t_{\text{setting}}} \times 100\% \text{ (Equation 8)}$$

This formula allowed us to quantify the discrepancy between the programmed and measured values, providing a metric for assessing the temporal accuracy of the FIMOSS implants. By analyzing these deviation rates, we were able to assess the precision and reliability of the FIMOSS implant in delivering optical stimulation according to the setting parameters.

8. Animals

All procedures were approved by the Animal Care and Use Committee of Huashan Hospital of Fudan University. Male Thy1-ChR2-EYFP mice were initially acquired from the Jackson Laboratory. (<https://www.jax.org/strain/012350>) All animals were housed at 22 °C, with 12-h light/dark cycles. Room humidity was controlled at 50%. All experiments were conducted during the light cycle.

9. Traumatic brain injury

TBI was induced using a well-established procedure as previously described¹. Adult mice, aged 8-10 weeks and weighing between 22 and 25 g, were selected as subjects. In brief, mice were anesthetized with 1% pentobarbital sodium (0.15ml/25g; Mytechnologies Technologies) and placed in a stereotaxic apparatus (RWD Technology Corp. Ltd., Shenzhen, China), with the skull exposed through a midline scalp incision. A 5.0-mm-diameter craniectomy, involving the removal of a part of the skull, was performed using an electric microdrill. The coordinates of the craniectomy were anteroposterior (AP) = -1.0 to +2.0 mm and mediolateral (ML) = 0.5 to 3.5 mm. Following the craniectomy, a contusion was induced using controlled cortical impact (CCI) with equipment from Virginia Commonwealth University (VCU), featuring a pounding head with a diameter of 3.0 mm²⁻⁴. The impact contusion depth was set at 1.2 mm from the dura, with a preset velocity of 4.0m s⁻¹ sustained for 150ms. These injury parameters were selected to target the forelimb motor cortex of the left hemisphere. Absorbable hemostatic sponges were utilized to control bleeding, saturate the skin, and maintain temperature throughout the procedure. Mice from both the TBI and TBI+CC7 group were performed TBI surgery, while the TBI surgery wasn't performed in control group.

10. Contralateral cervical seventh nerve transfer

Contralateral cervical seventh nerve transfer surgery was conducted following previously established procedures^{5,6}. In brief, after anesthetizing and positioning the mouse in a supine posture, a supraclavicular incision was made to expose the sternum. A 3-mm median sternotomy incision was performed to reveal the bilateral common carotid artery. At the lateral

edge of the left internal jugular vein, the fascia and adipose tissue were retracted to expose the brachial plexus. The superior trunk, comprising the C5 and C6 nerves, had three branches, while the middle trunk (C7 nerve) and inferior trunk (C8 and T1 nerves) could be identified along the upper trunk to the mouse's tail.

On the left side (donor side), the anterior and posterior divisions of the middle trunk (C7 nerve) were dissected distally to the division-to-cord level under the clavicle. The C7 nerve was blocked with 2% lidocaine and resected at its merging points with the lateral cord and posterior cord. Following blockade with 2% lidocaine, the left C7 nerve was exposed and cut as distally as possible. On the right side (injured side), the anterior scalene muscle was severed similarly to the left side, and the right C7 nerve root was transected near the intervertebral foramen. The right C7 nerve was dissected to its division level. Partial removal of the longus colli muscle beside the vertebral bodies was performed on both sides. The space between the trachea-esophagus and vertebral body was bluntly separated and expanded. Subsequently, the C7 nerve was pulled out beneath the common carotid artery, the phrenic nerve, the vagus nerve, and the trachea-esophagus. It's important to note that, unlike humans, the mouse's esophagus is positioned side by side with the trachea on the left side.

The proximal stump of the left C7 nerve was attached to the distal stump of the right C7 nerve using 12-0 prolene sutures via the prespinal route. In line with CC7 surgery, the C7 nerves on both sides were exposed for sham surgery in TBI and control group.

11. Catwalk gait analysis

1 month after FIMOSS implantation, motor function was evaluated with a Catwalk gait analysis system (Gait analysis and processing system ZS-BT/S, Zhongshi Science & Technology, Beijing, China). Mice were pre-trained to conduct the experiment for 3 days. The system can visualize the footprints and calculates parameters related to print dimensions, as well as time and distance relationships between footfalls. 3 compliant runs were performed per mouse and the mean value were calculated for data analysis afterwards. Print area, stride length, base of support (forelimbs), swing time and stance time were calculated automatically and selected to evaluate the effect of FIMOSS implantation in brachial plexus to mice.

12. Motion analysis of forelimbs

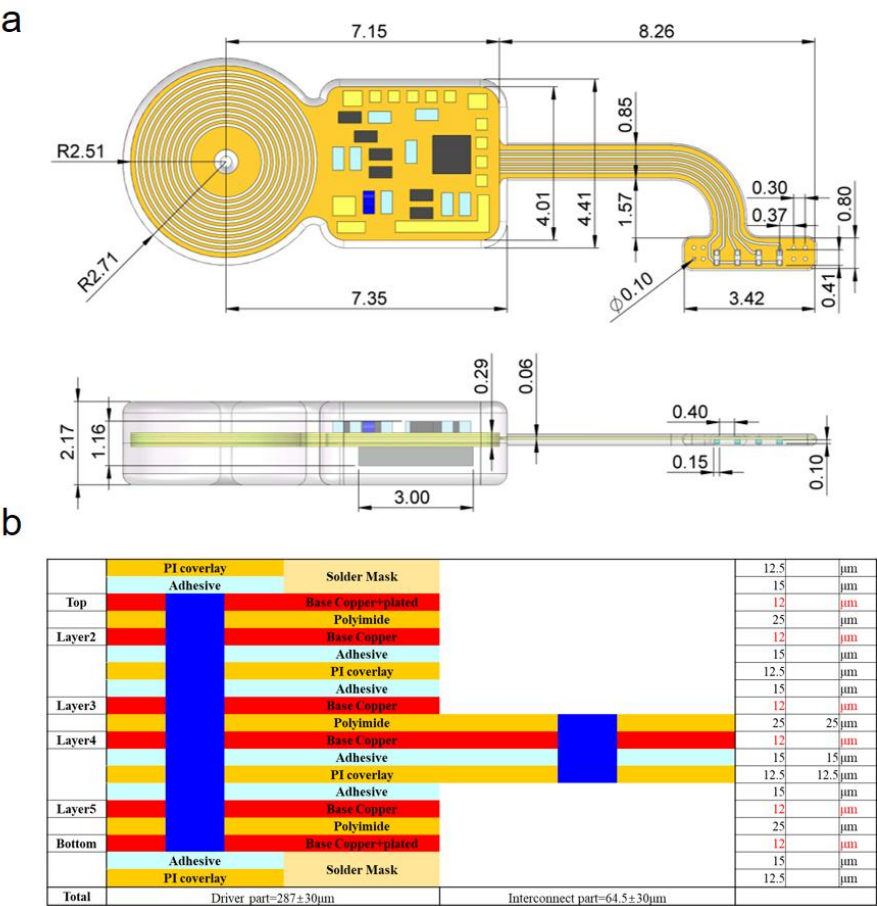
The motion analysis was used to assess the potential nerve damage caused by the implantation of the FIMOSS implant by accurately quantifying the activity of each joint in the forelimb during free walking^{7,8}. In this experiment, all the mice were pre-trained to run freely along a straight glass corridor. After training, the mice of control group and upper, middle, lower trunk implantation group were tested with the right forelimb hair removed. A 240 Hz high-speed camera was placed 0.2m away from the corridor to capture the trajectory of the forelimb. Afterwards, DeepLabcut Toolbox 2.2.1 was utilized to trace the kinematic trajectory through deep learning⁹⁻¹¹. The angle changes of multiple joints in the forelimb were then calculated as the differences between the maximum and minimum. The experiments are repeated 5 times for each mouse, and the mean value was calculated for subsequent statistical analysis to reflect the motor function of the forelimb.

13. Immunofluorescence staining

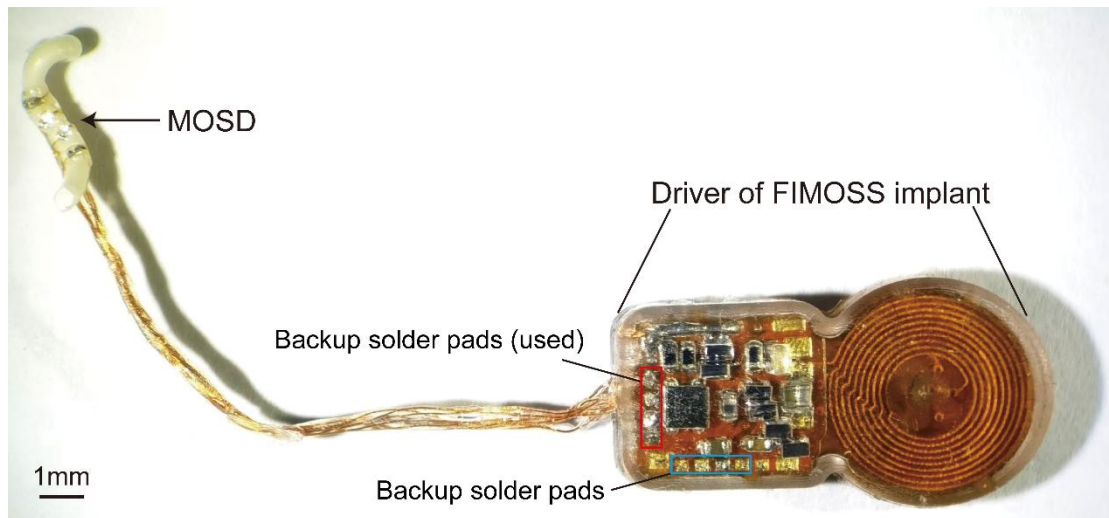
The slices (cross-sections, 5 μ m thick) were washed with 0.01M PBS (pH=7.4) 3 times (5 min each) and permeabilized in 0.3% Triton X-100 PBS solution for 10 min. The slices were then blocked in 10% normal goat serum for 30 min at room temperature and incubated with primary antibodies overnight at 4°C (Rabbit anti-iba-1 antibody, Abcam, ab178846, 1:500; Rat anti-MBP, Abcam, ab7349, 1:500). The slices were rewashed with 0.01M PBS 3 times (5 min each). Secondary antibodies (Goat anti-rat Alexa Fluor 488, Abcam, ab150157, 1:500; Goat anti-rabbit Alexa Fluor 594, Abcam, ab150080, 1:500) were applied to the slices and incubated at room temperature for approximately 1.5h in the dark. Then the slices were washed 3 times (5 min each). Finally, the slides were mounted with DAPI Fluoromount-G (SouthernBiotech).

Nikon Eclipse C1 was used for the photographs. The quantitative analysis of mean sheath thickness and were performed in ImageJ.

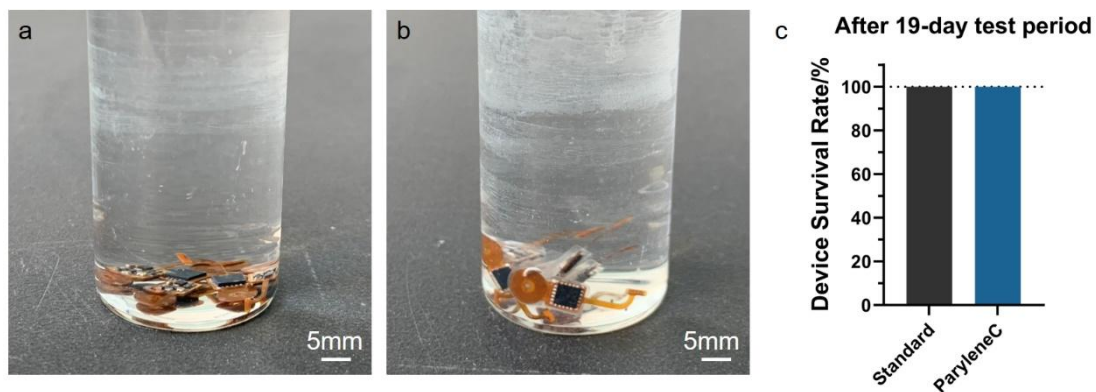
Supplementary Figures and Tables



Supplementary Fig.1 FIMOSS implant engineering drawing, and FPC layer management. **a** Engineering drawing of the FIMOSS implant with key dimensions annotated. Units are in millimeter (mm). **b** Layer stacking of the FIMOSS implant's printed circuit board

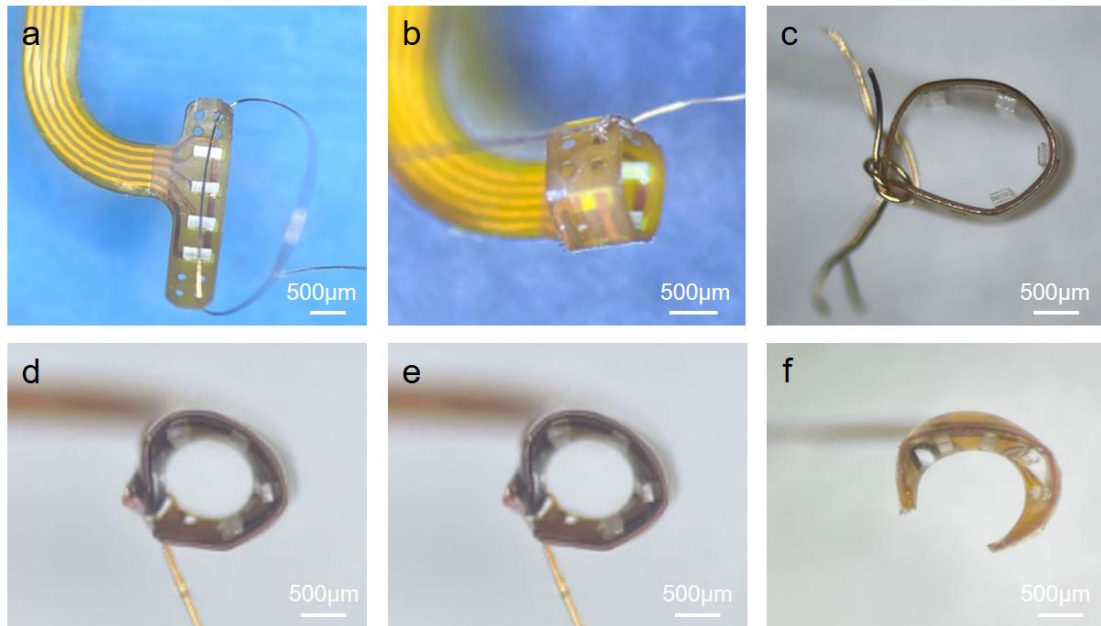


Supplementary Fig.2 A photo of the FIMOSS driver soldered with a 4-channel MOSD and with complete encapsulation. (scale bar=1mm)

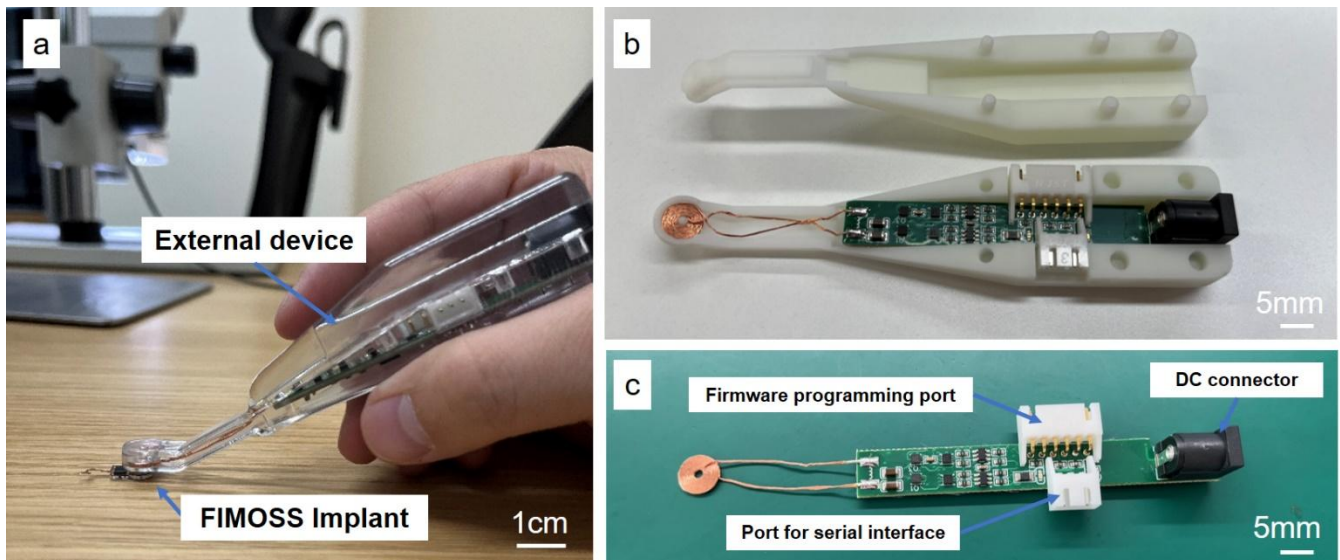


Supplementary Fig.3 Accelerated aging test of FIMOSS

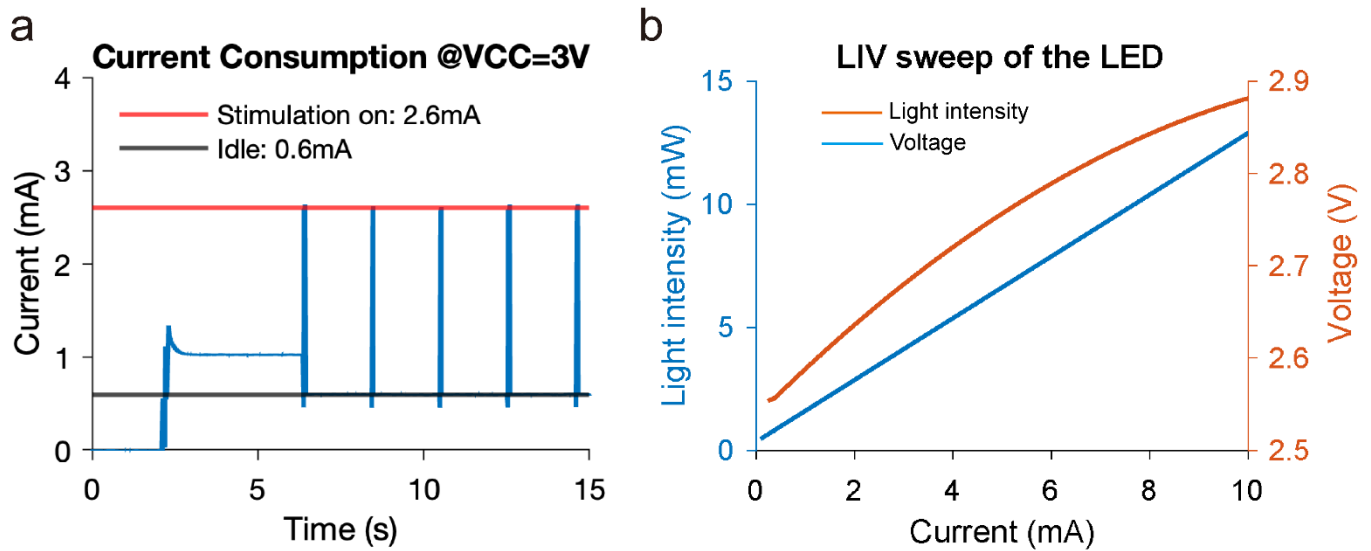
encapsulation in vitro. a 5 FIMOSS implants encapsulated only with 12 μ m Parylene C coating in 60°C saline solutions. (scale bar=5mm) **b** 5 FIMOSS implants encapsulated with standard encapsulation (12 μ m Parylene C coating and 500 μ m PDMS casing) in 60°C saline solution. (scale bar=5mm) **c** Device survival rates after 19-day accelerated aging test showed the reliability of FIMOSS implants encapsulation.



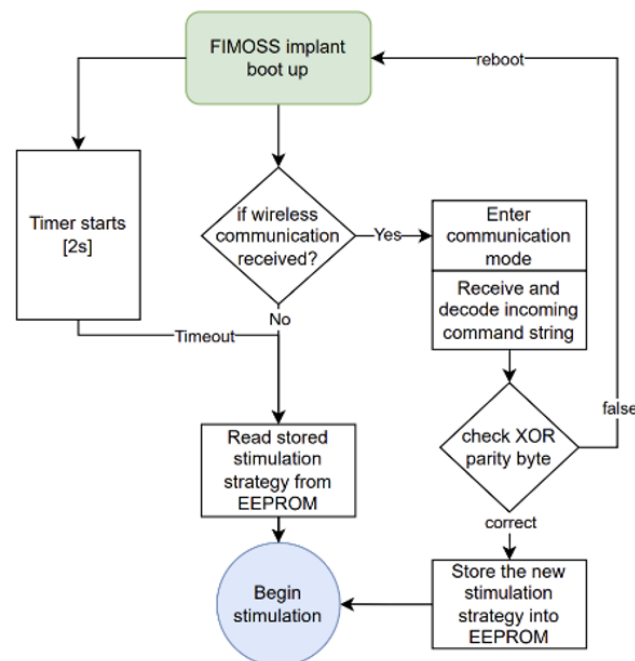
Supplementary Fig.4 Pre-curling process of the MOSD II. a~c During the pre-curling process of the MOSD II, copper wire with a diameter of 0.01mm was used to stitch the two suture eyelets to crimp the MOSD II into a cuff. **d** The FIMOSS implant was treated with plasma gas, and a layer of PDMS with a thickness of about 150µm was encapsulated on the interconnect and MOSD II, and cured in an oven at 85°C for 30min. **e,f** After the FIMOSS implant is cooled to room temperature, use surgical micro-scissors to remove the copper knot and the lateral suture eyelets. Finally, new PDMS mixture was applied to the cut section and cured again in an oven at 85 °C for 30min. (scale bar=500µm)



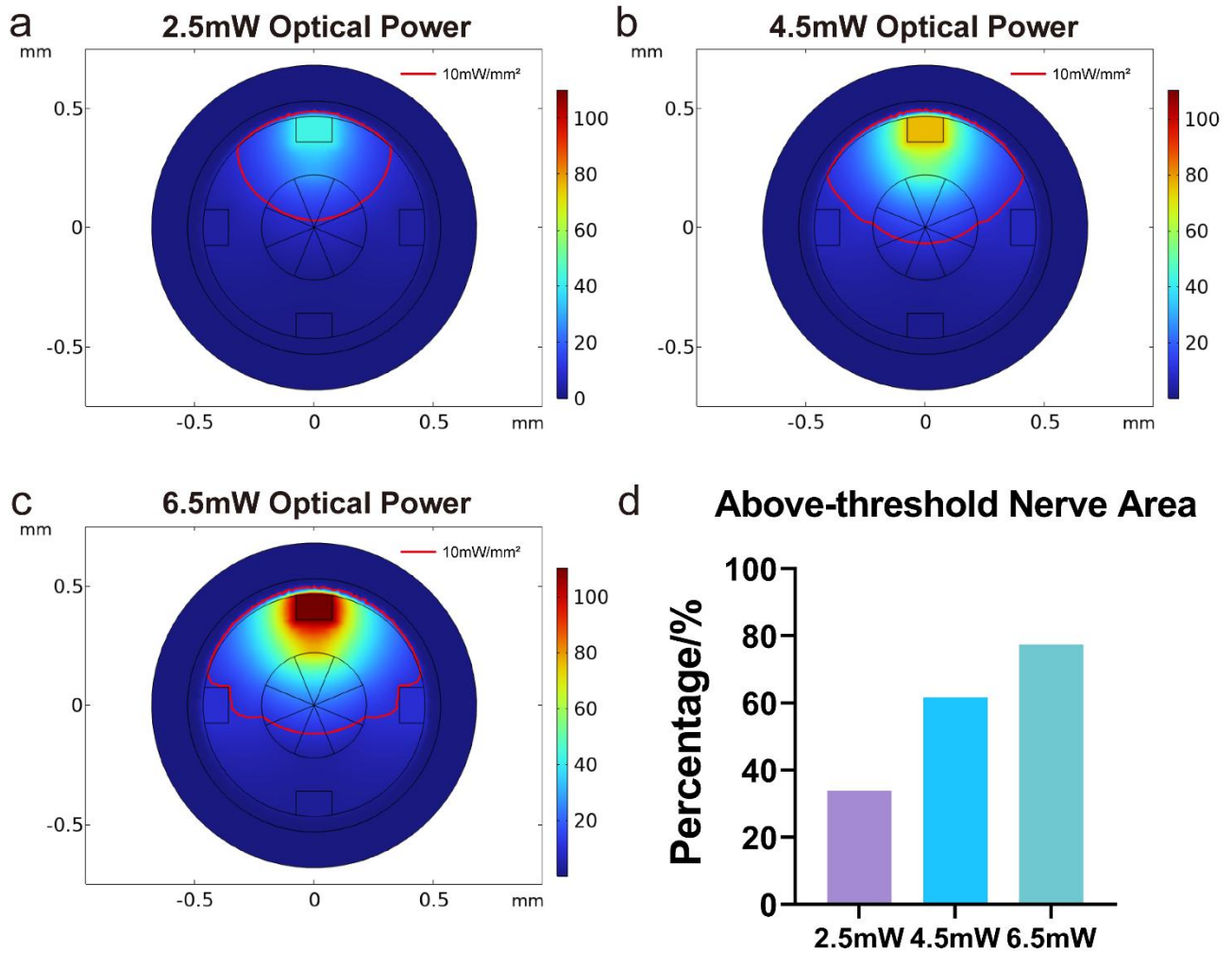
Supplementary Fig.5 FIMOSS external device. **a** The external device is designed to be hand-held for intraoperative hand-held use to power the implant. (scale bar=1cm) **b** The FIMOSS external device consists of a 3D printed housing and internal electronics (scale bar=5mm). **c** The FIMOSS external device includes a DC connector for DC power supply, and two other connectors for firmware programming and serial interface with a personal computer to set updated stimulation parameters. The left end of the PCB is connected with a transmitting coil for the wireless interface with the implant (scale bar=5mm).



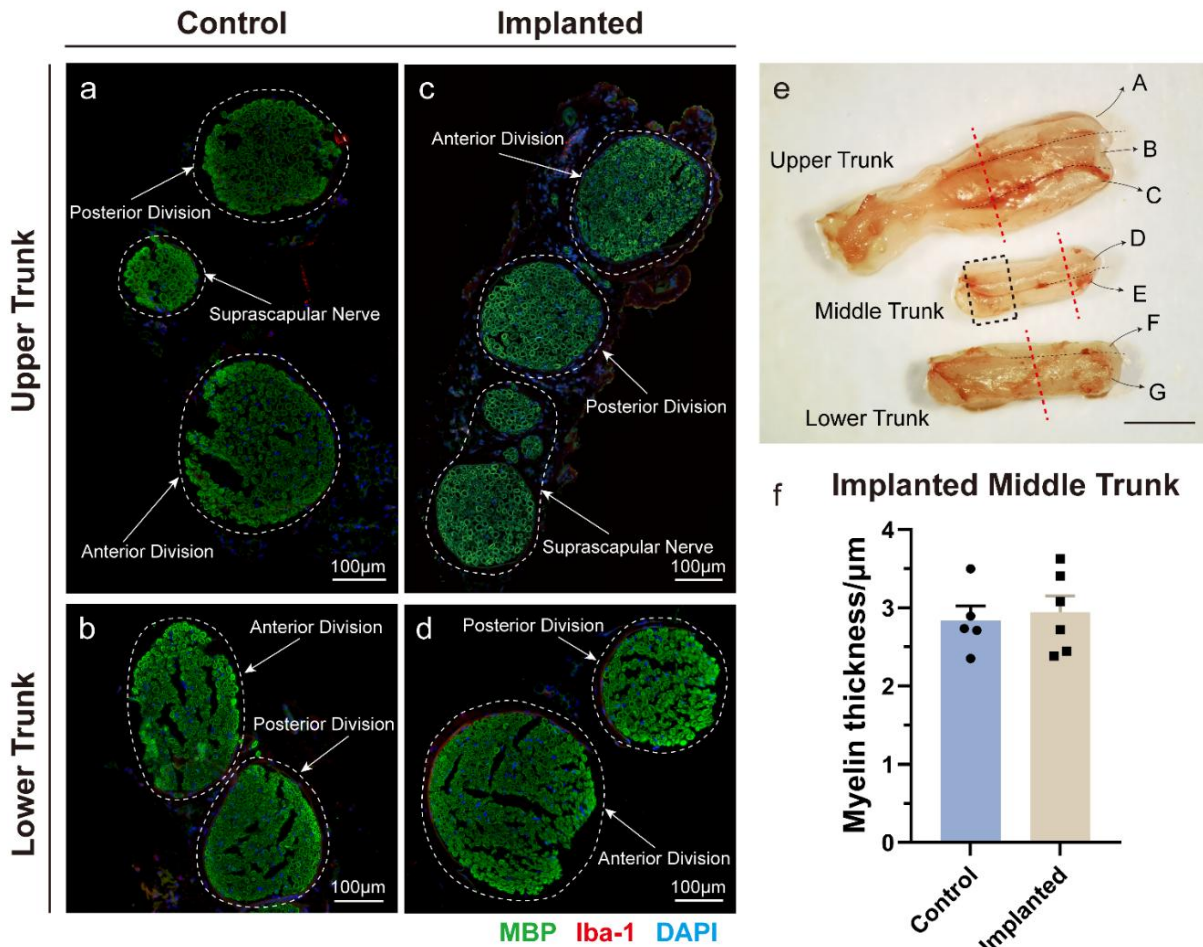
Supplementary Fig.6 Power consumption of FIMOSS implant and LIV characterization of LED. **a** Power consumption of the FIMOSS implant in a typical stimulation event. **b** Luminous intensity, current and voltage across the LED were measured simultaneously to obtain the LED's LIV characterization.



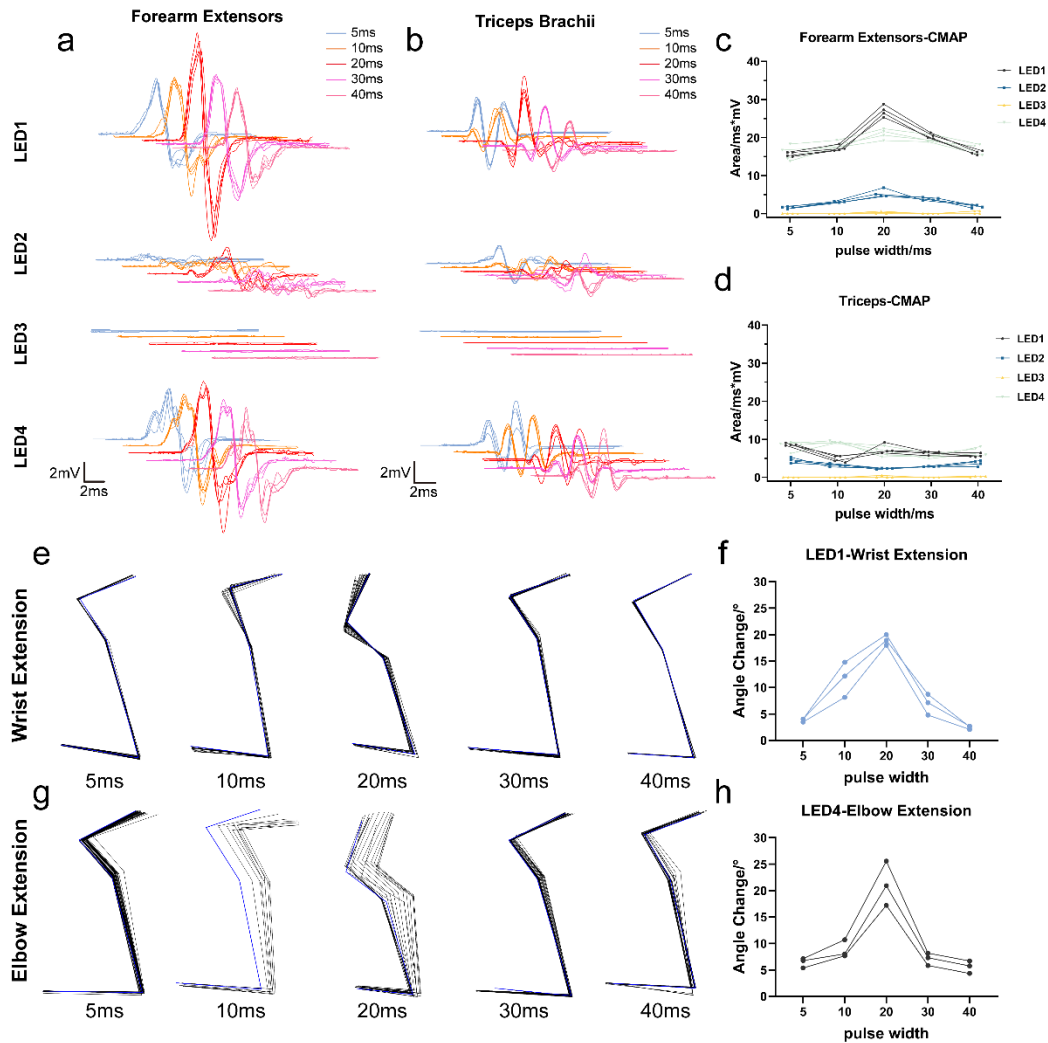
Supplementary Fig.7 FIMOSS implant firmware schematics



Supplementary Fig.8 Optical simulation of light irradiance distribution in the target nerve when illuminated by different optical power of the μ LED. a,b,c Heat map of light irradiance in a representative 2D slice. One μ LED was illuminated at optical power of 2.5mW(a), 4.5mW(b) or 6.5mW(c) respectively. The color bar represents light irradiance in mW/mm². The contour lines of 10mW/mm² were depicted in red. **d** Comparison between percentage of nerve cross-sectional area where light irradiance exceeds 10mW/mm², with optical power of 2.5mW, 4.5mW and 6.5mW.

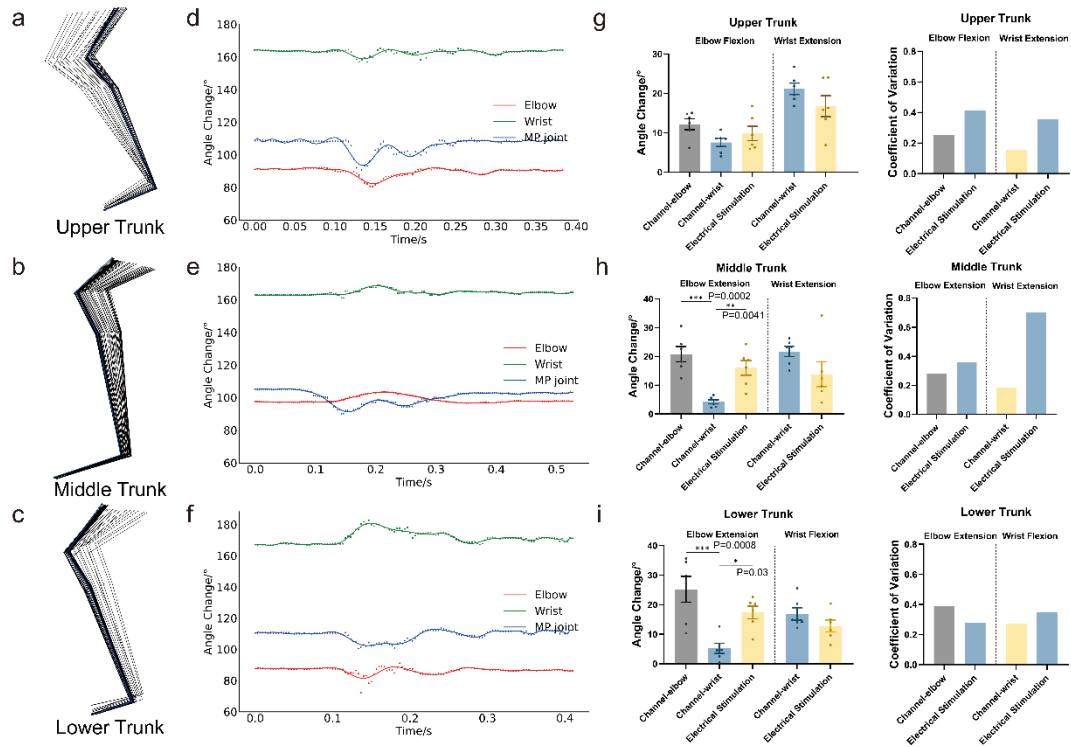


Supplementary Fig.9 Immunofluorescence staining of upper and lower trunk and myelin thickness analysis of implanted middle trunk. **a~d** Representative immunofluorescence staining image of adjacent upper trunk and lower trunk of mouse from control group (a,b) and middle trunk implantation group (c,d). (scale bar=100 μm). **e** A photograph of the harvested brachial plexus nerve trunks. The black dashed box indicates the implantation site of MOSD II, while the 3 red dashed lines represent: (1) the position adjacent to MOSD II on the upper trunk; (2) the distal site of MOSD II implantation position on the middle trunk; (3) the position adjacent to MOSD II on the lower trunk. Cross sections of neural tissues from all 4 positions were prepared for immunofluorescence staining. A, suprascapular nerve. B, posterior division of upper trunk. C, anterior division of upper trunk. D, anterior division of middle trunk. E, posterior division of middle trunk. F, posterior division of lower trunk. G, anterior division of lower trunk. (scale bar=500 μm) **f** Comparison between myelin thickness of middle trunk at the implantation site from control group (n=5) and implanted group (n=6).

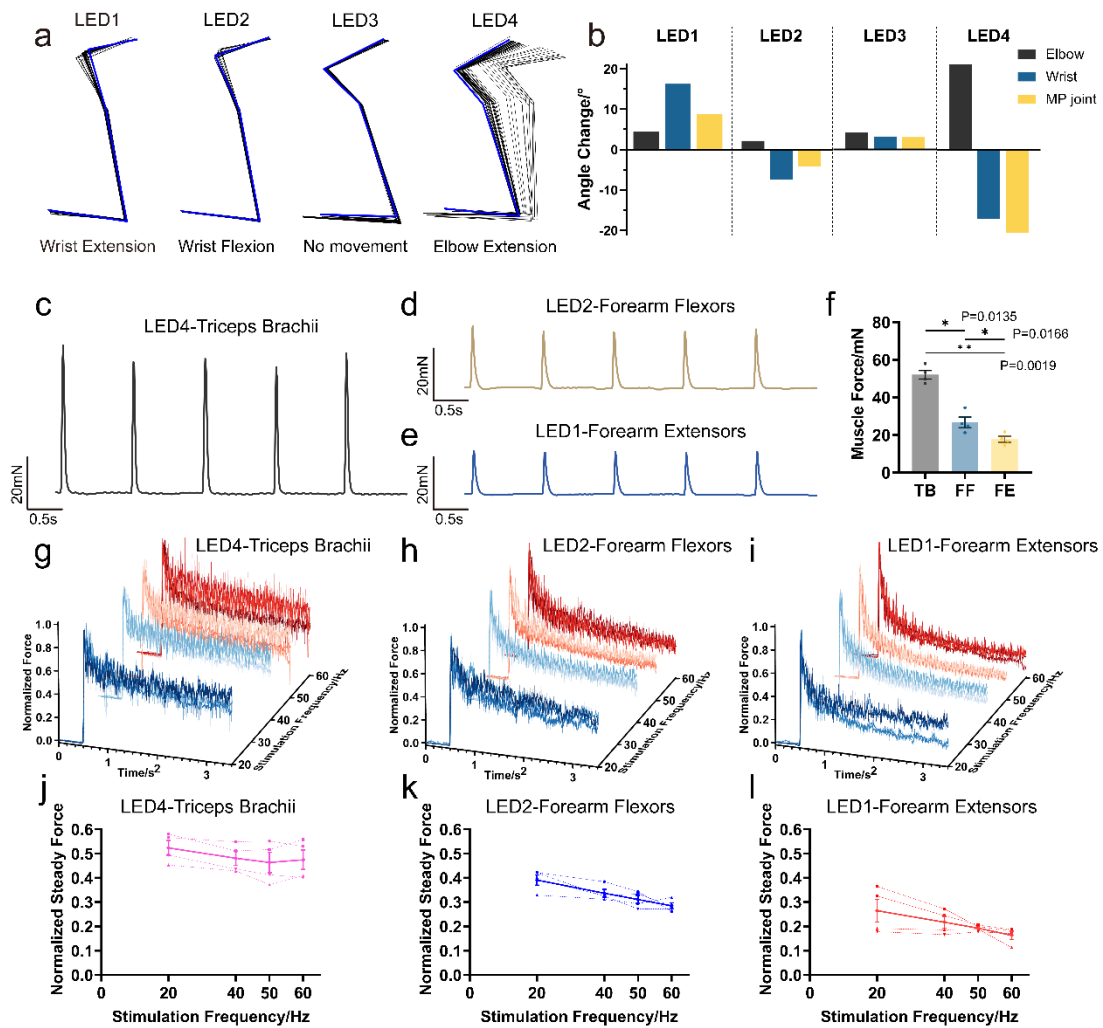


Supplementary Fig.10 Comparison of CMAP area and distinct forelimb movement induced by different pulse widths. a,b

Representative CMAP curve recorded from forearm extensors (a) and triceps brachii (b) with different stimulation pulse width when illuminating different LEDs. Rows 1 to row 4 display CMAP curves induced by LED1-LED4 respectively. 5ms, blue; 10ms, orange; 20ms, red; 30ms, magenta; 40ms, pink. **c,d** Comparison of CMAP area recorded from forearm extensors (c) and triceps brachii (d) when illuminating LED1 and LED4 respectively with different pulse widths. **e~h** Representative trajectories of wrist extension (e) and elbow extension (g) with different pulse-width. Column 1 to column 5 display representative induced forelimb trajectories with stimulation pulse width of 5ms, 10ms, 20ms, 30ms and 40ms respectively. Quantitative analysis of angle changes in wrist extension (f) and elbow extension (h) induced by LED1 and LED4 respectively with different pulse widths.

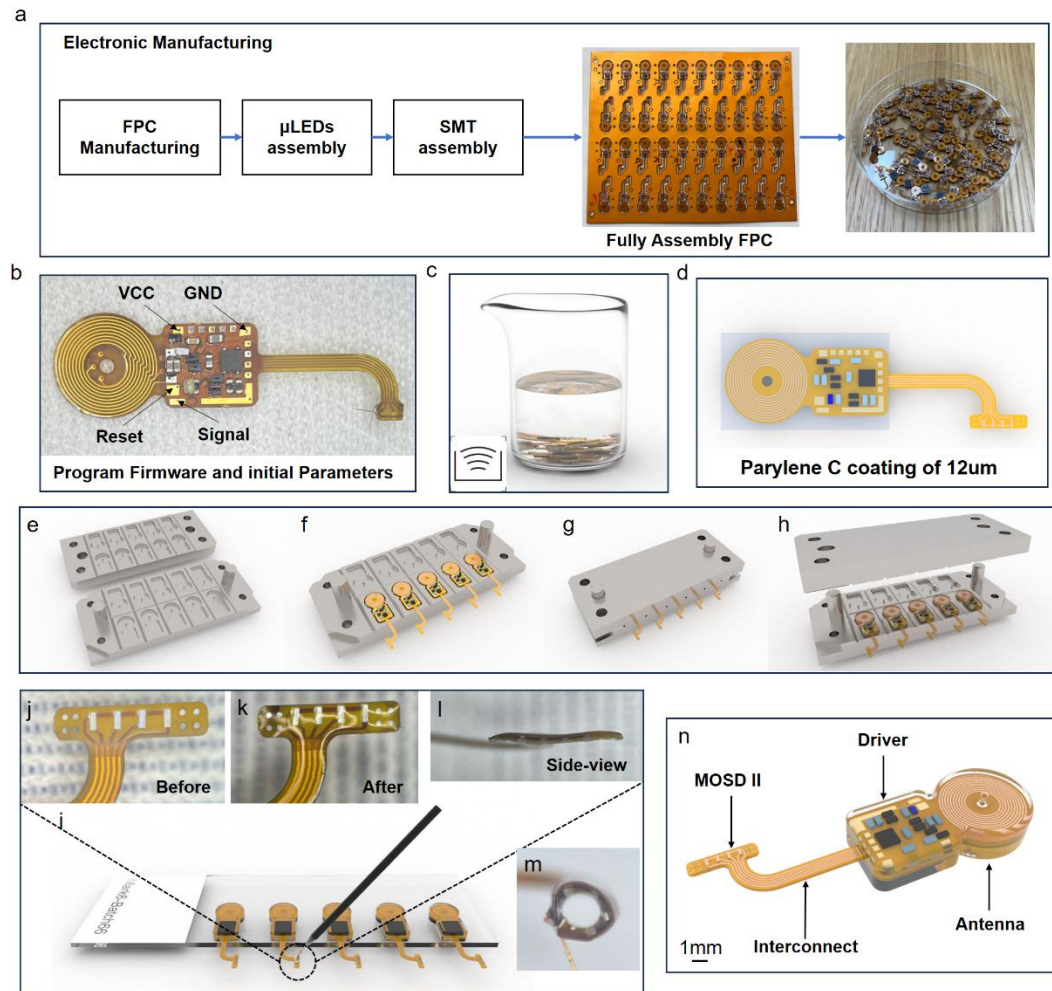


Supplementary Fig.11 Comparison between multisite optogenetic stimulation/electrical stimulation-induced forelimb movements of different nerve trunks in brachial plexus. **a~c** Representative trajectories induced by electrical stimulation on upper (a), middle (b) and lower trunk (c). **d~f** The angle-time curves of elbow, wrist and MP joint movements induced by electrical stimulation of the upper (d), middle (e) and lower trunk (f). **g~i** Comparison between angle changes (left) and coefficient of variation (right) of multisite optogenetic stimulation (n=6)/electrical stimulation-induced (n=6) forelimb movements at different brachial plexus nerve trunks. Channel elbow/wrist represent the μ LED which can induce elbow/wrist extension or flexion with the largest angle changes among the 4 μ LEDs of MOSD II.



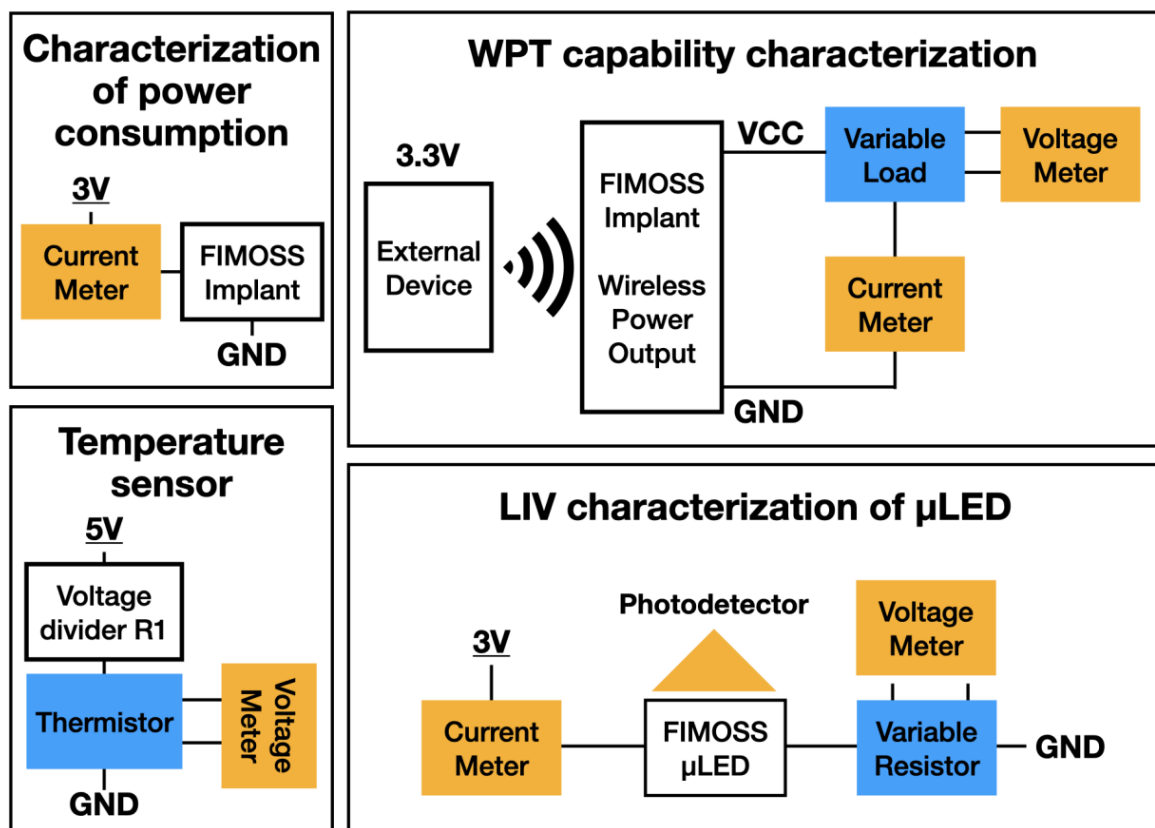
Supplementary Fig.12 Distinct forelimb muscle contractions induced by multisite optogenetic stimulation. **a** Representative trajectories of distinct forelimb movements induced by different μ LEDs. **b** Quantitative analysis of angle changes from different forelimb joints induced by FIMOSS implant. **c~e** Schematic images showing muscle force recordings of triceps brachii (c), forearm flexors (d) and forearm extensors (e) twitch induced by LED4, LED2 and LED1 respectively. (1Hz, 20ms pulse width, default wireless condition) **f** Comparison of twitch force between different muscle groups innervated by lower trunk. TB, triceps brachii. FF, forearm flexors. FE, forearm extensors. One-way ANOVA and multiple comparison tests with Dunnett's correct. Data are presented as mean $\pm$ s.e.m. (n=4, *P < 0.05, **P < 0.01) **g~i** Normalized force of triceps brachii (g), forearm flexors (h) and forearm extensors (i) tetanic contraction induced by multisite optogenetic stimulation of lower trunk with different stimulation frequency (20Hz/40Hz/50Hz/60Hz stimulation frequency, 0.83ms pulse width, default wireless condition) (n=4). **j~l** Normalized steady force of

triceps brachii (j), forearm flexors (k) and forearm extensors (l) with the increase of stimulation frequency. (pulse width=0.83ms, default wireless condition) The curve of each individual mouse is represented by a dashed line, and mean curve of all mice is represented by a solid line. (n=4, mean±s.e.m.)



Supplementary Fig.13 Fabrication process of FIMOSS implant. **a**

Electronic manufacturing process of FIMOSS implants involving the FPC manufacturing, μ LEDs assembly and SMT assembly. **b** Program firmware and initial parameters into the MCU of the FIMOSS implant. **c** The ultrasonic cleaning of the device. **d~h** The antennas and drivers were encapsulated by 12 μ m Parylene C (d) and then encapsulated by PDMS using a stainless steel mold (e~h) **i~l** Encapsulate the interconnect and MOSD II of several FIMOSS implants by PDMS. **m** Fixation of MOSD II by a 11-0 prolene suture. **n** A schematic diagram of the completely prepared FIMOSS implant. (scale bar=1mm)



Supplementary Fig.14 A schematic diagram of experiments on several device characterization

Byte	Information	Example
1	Header byte (Start Command)	0x55
2~4	First optical stimulation	0xFF (channel-selection, LED 1) 0xFF (pulse width, 200ms) 0xDA (inter-pulse interval, 2000ms)
5~7	Second optical stimulation	0xFF (channel-selection, LED 2) 0xFF (pulse width, 200ms) 0xDA (inter-pulse interval, 2000ms)
8~10	Third optical stimulation	0xFF (channel-selection, LED 3) 0xFF (pulse width, 200ms) 0xDA (inter-pulse interval, 2000ms)
11~13	Fourth optical stimulation	0xFF (channel-selection, LED 4) 0xFF (pulse width, 200ms) 0xDA (inter-pulse interval, 2000ms)
14	XOR parity byte	Automatically calculated by FIMOSS external device=XOR (byte 2~13)

Supplementary Table 1 Specification for wireless communication command train.

Index	Hex	Channel selection
1	FF	LED 1
2	FE	LED 2
3	FD	LED 3
4	FC	LED 4

Supplementary Table 2 Look-up table for hex representation of the channel selection.

Index	Hex	Binary	Pulse width	Inter-pulse interval
Example	-	1XX1 XX1X	0~150ms, 200ms	0~3s, 30s
1	92	1001 0010	0ms	0ms
2	93	1001 0011	5ms	100ms
3	96	1001 0110	10ms	200ms
4	97	1001 0111	15ms	300ms
5	9A	1001 1010	20ms	400ms
6	9B	1001 1011	25ms	500ms
7	9E	1001 1110	30ms	600ms
8	9F	1001 1111	35ms	700ms
9	B2	1011 0010	40ms	800ms
10	B3	1011 0011	45ms	900ms
11	B6	1011 0110	50ms	1000ms
12	B7	1011 0111	55ms	1100ms
13	BA	1011 1010	60ms	1200ms
14	BB	1011 1011	65ms	1300ms
15	BE	1011 1110	70ms	1400ms
16	BF	1011 1111	75ms	1500ms
17	D2	1101 0010	80ms	1600ms
18	D3	1101 0011	85ms	1700ms
19	D6	1101 0110	90ms	1800ms
20	D7	1101 0111	95ms	1900ms
21	DA	1101 1010	100ms	2000ms
22	DB	1101 1011	105ms	2100ms
23	DE	1101 1110	110ms	2200ms
24	DF	1101 1111	115ms	2300ms
25	F2	1111 0010	120ms	2400ms
26	F3	1111 0011	125ms	2500ms
27	F6	1111 0110	130ms	2600ms
28	F7	1111 0111	135ms	2700ms
29	FA	1111 1010	140ms	2800ms
30	FB	1111 1011	145ms	2900ms
31	FE	1111 1110	150ms	3000ms
32	FF	1111 1111	200ms	30s

Supplementary Table 3 Look-up table for hex representation of the parameter pulse width and inter-pulse interval.

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