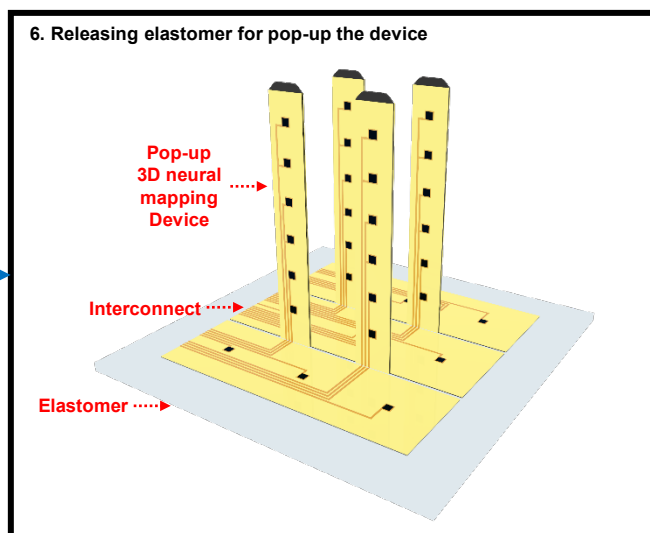
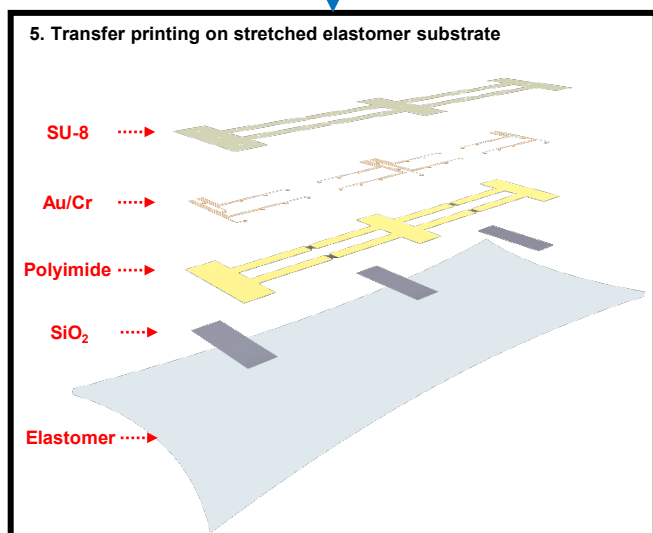
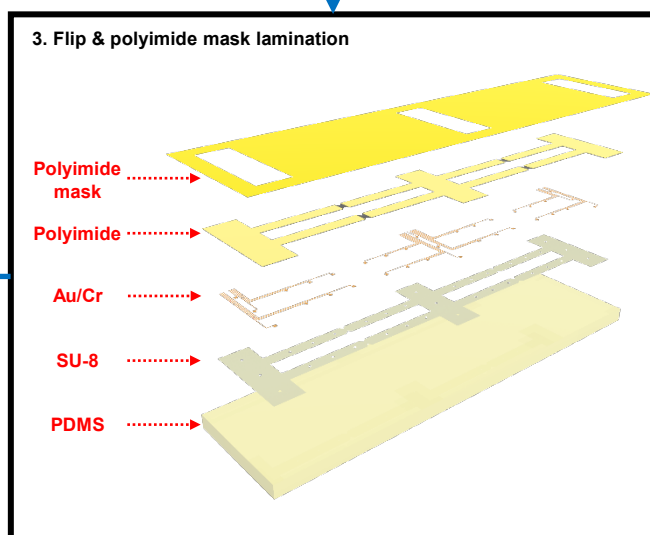
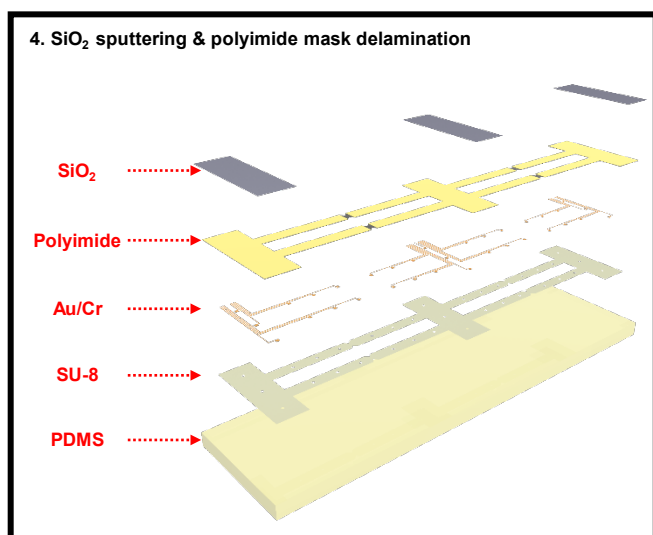
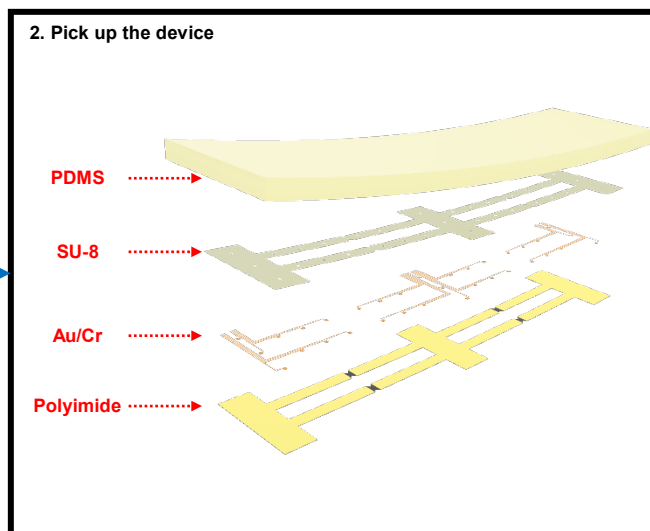
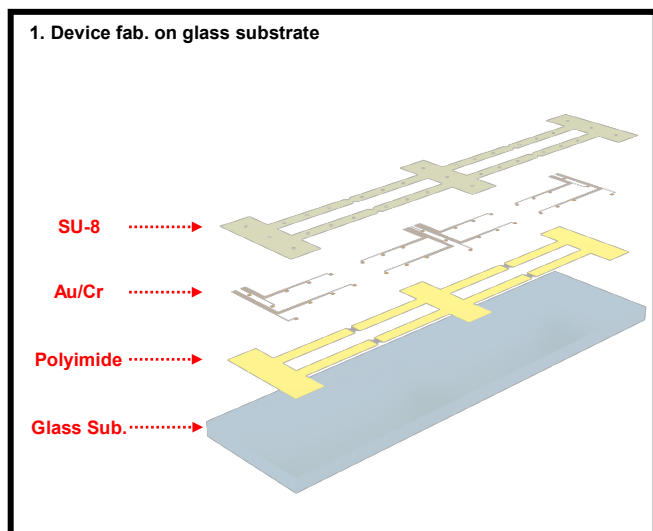
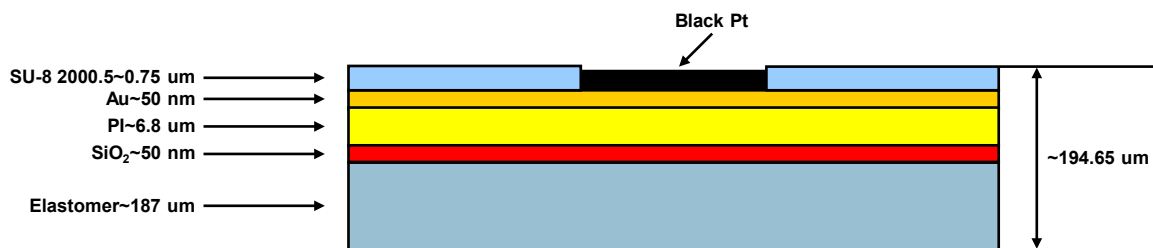
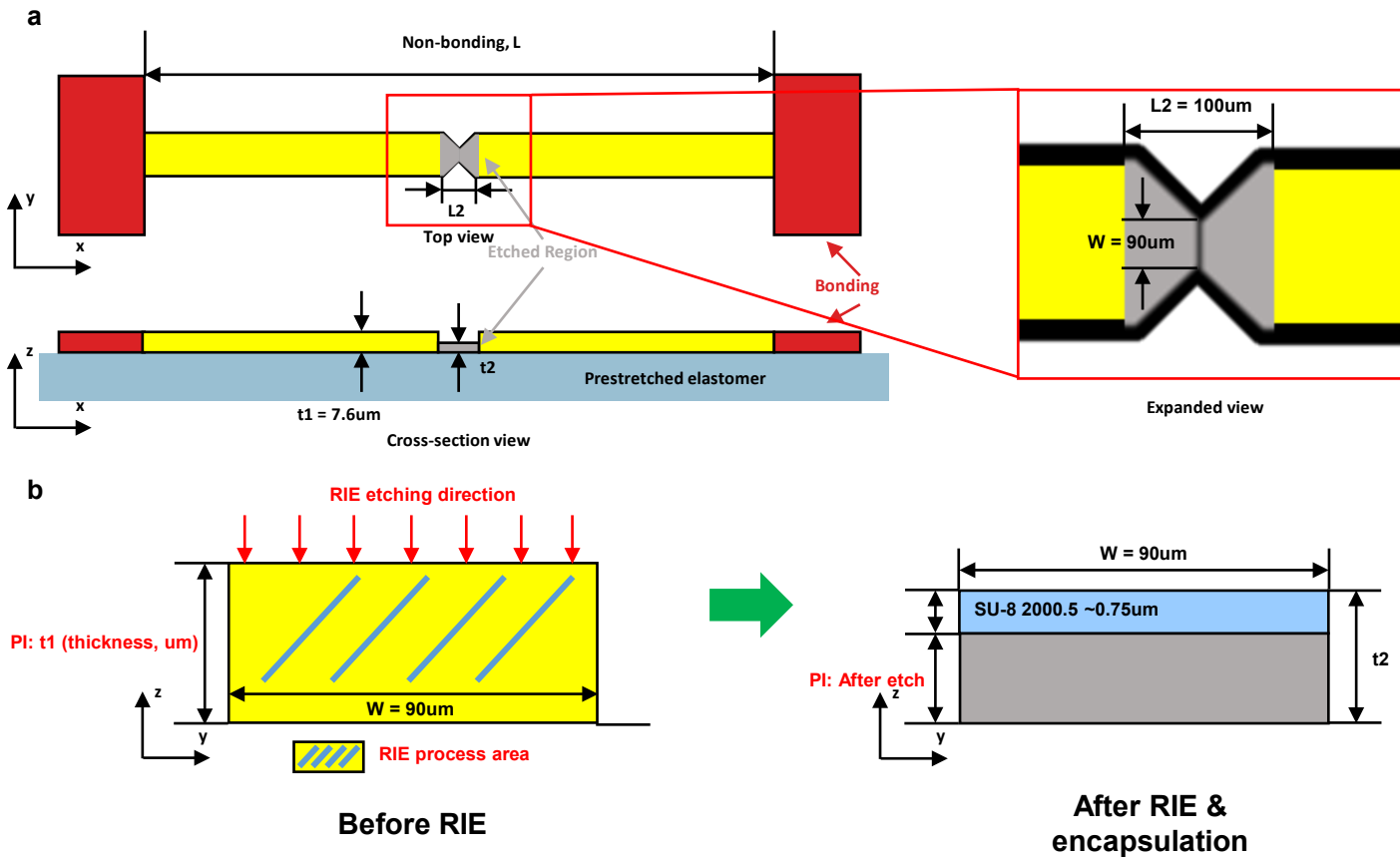




Supplementary Figure 1 | Procedures for fabricating 3D electrode pop-up structure process



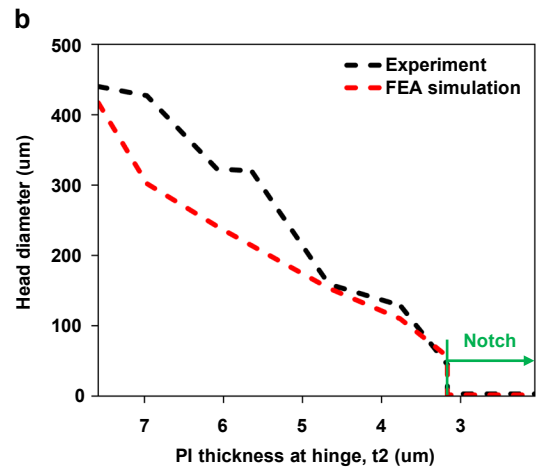
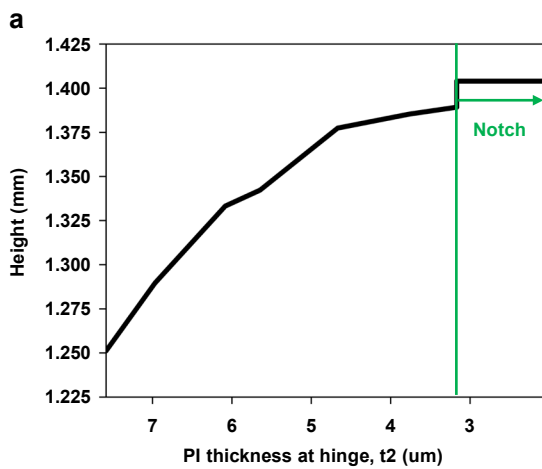
Supplementary Figure 2 | Illustration of the cross-sectional view of the 3D brain mapping electrode array



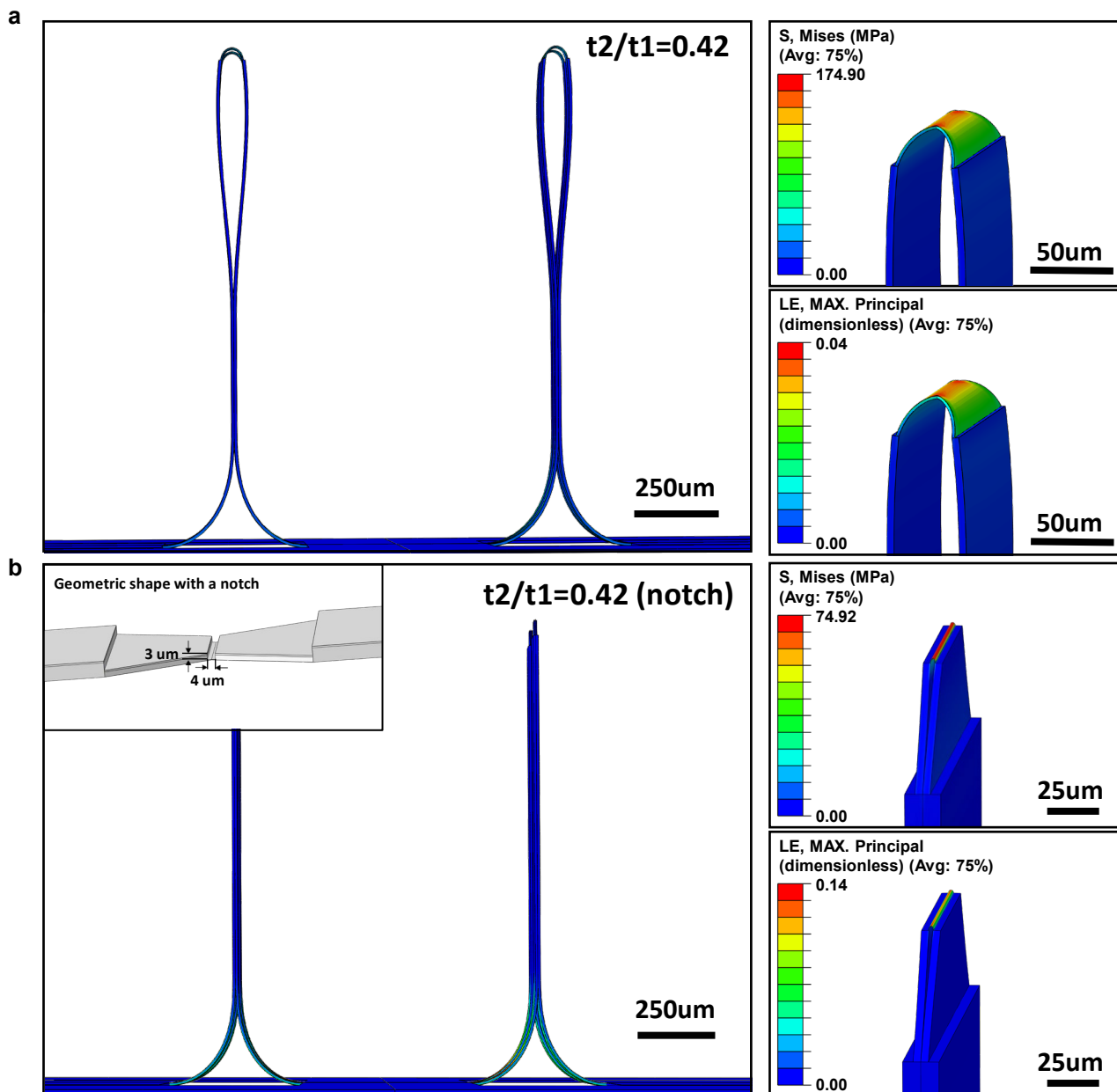
Supplementary Figure 3 | 3D brain mapping electrode hinge etching area & cross-sectional view of RIE process

PI_Thickness: H (um)	6.835	6.22	5.335	4.895	3.9175	3.014	2.417	2.417	1.69	1.31
SU8_thickness (um)	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
t2 (H+SU8) (um)	7.585	6.97	6.085	5.645	4.6675	3.764	3.167	3.167	2.44	2.06
ratio (t2/t1)	1	0.92	0.80	0.74	0.62	0.50	0.42	0.42	0.32	0.27
PI-SU8 Bilayer Bending Stiffness (mN*um)	142.47	111.22	74.755	60.019	34.413	18.325	11.032	0.00236	0.00236	0.00236
Head diameter (Experiment) (um)	440	427	323	320	159	129	45	3.05	3.05	3.05
Head diameter (FEA simulation) (um)	417	302	241.5	214	153.3	110	56.5	1.714	1.714	1.714
Height (mm)	1.25118	1.28955	1.33318	1.34228	1.3774	1.38534	1.38921	1.404	1.404	1.404

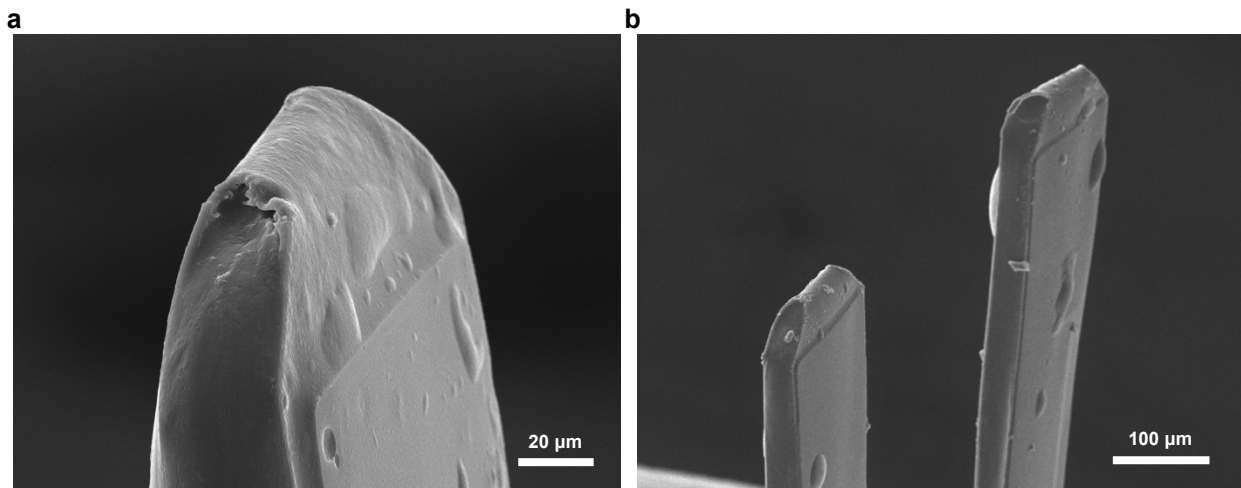
Supplementary Table 1 | 3D brain mapping electrode experimental & FEA simulation head diameter depending on thickness ratio



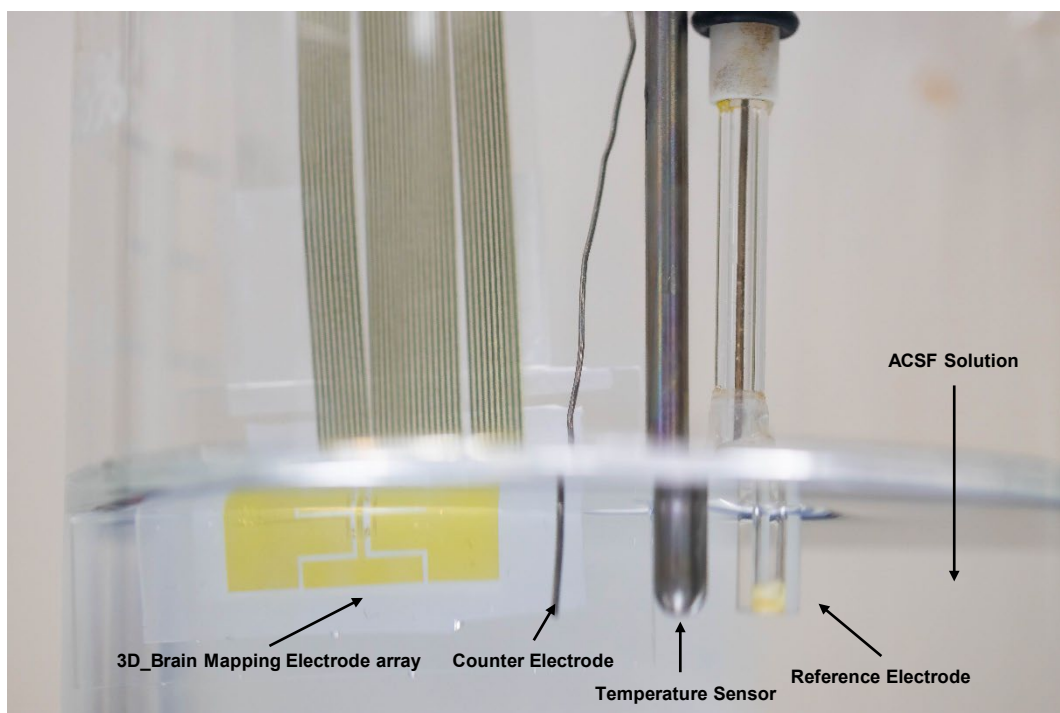
Supplementary Figure 4 | FEA simulation result about bending stiffness and head diameter with thickness ratio



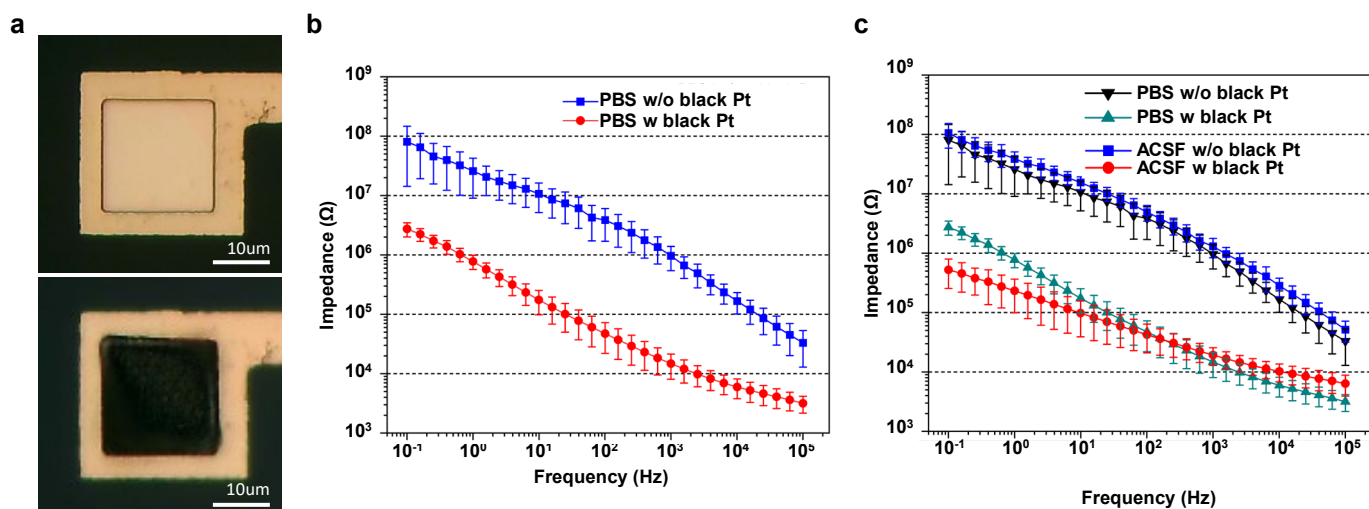
Supplementary Figure 5 | FEA simulation result about maximum principal logarithmic stain & Mises stress counter w and w/o notch



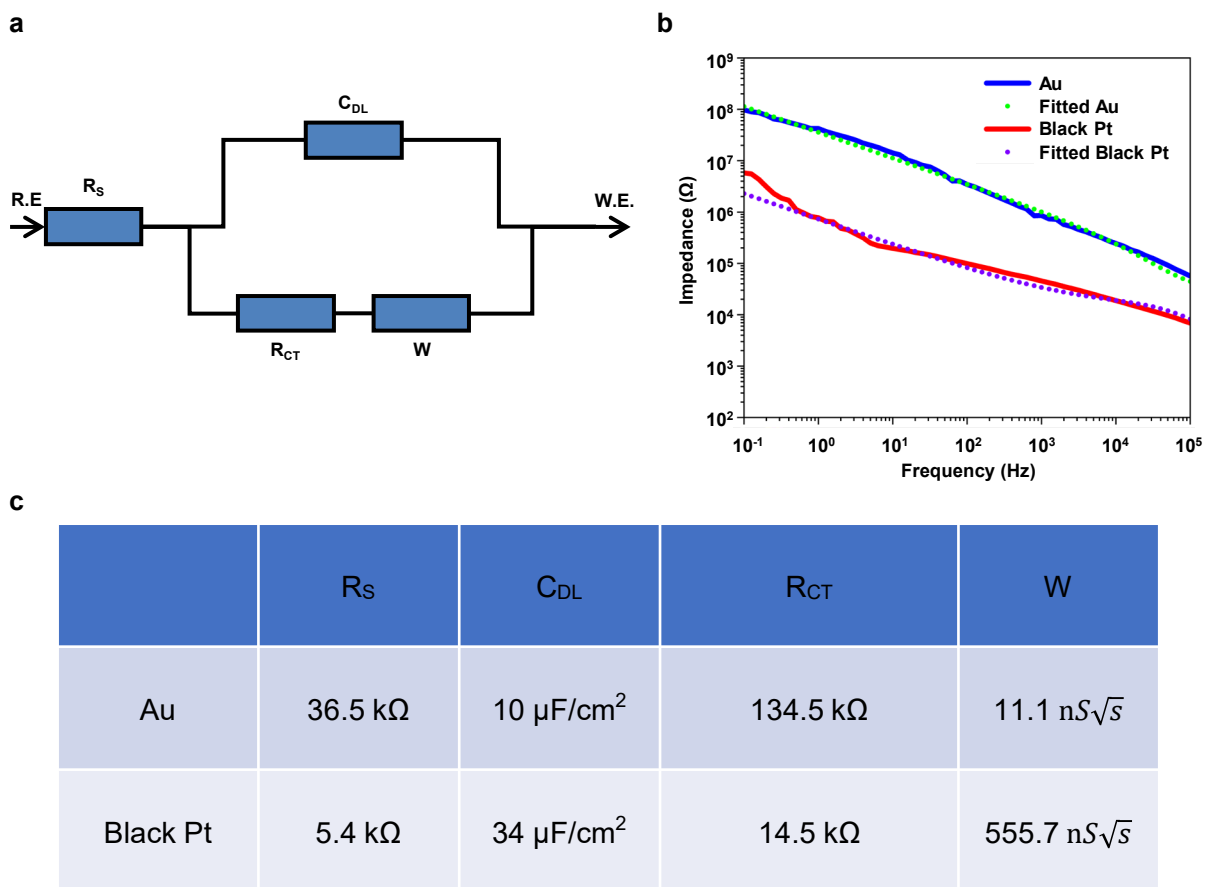
Supplementary Figure 6 | SEM image of PEG coated 3D electrode



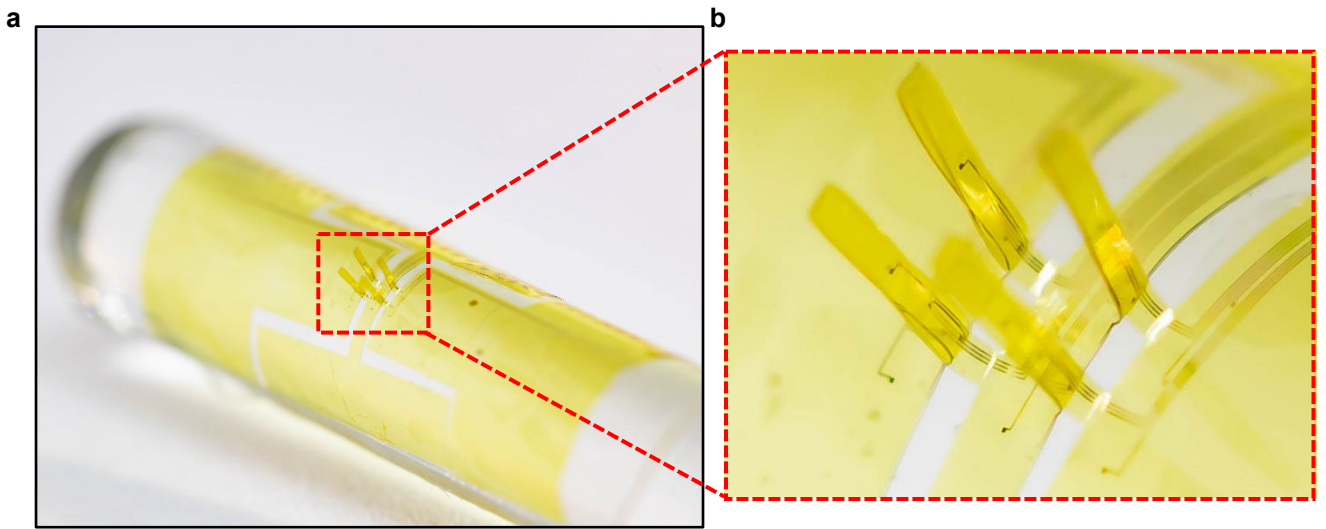
Supplementary Figure 7 | *In vitro* electrochemical impedance test setup photograph for 3D brain mapping electrode



Supplementary Figure 8 | PBS & ACSF electrochemical impedance test at 36.5°C with & without black Pt coating on electrode array



Supplementary Figure 9 | Schematic description for fitting EIS measurement equivalent Randles circuit model of Au and black Pt



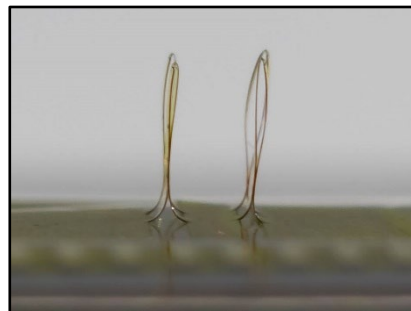
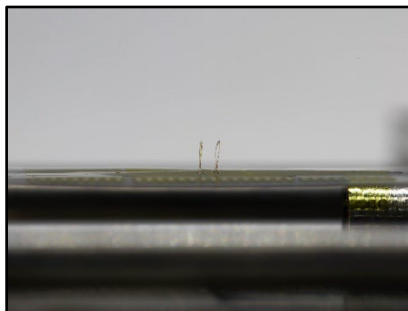
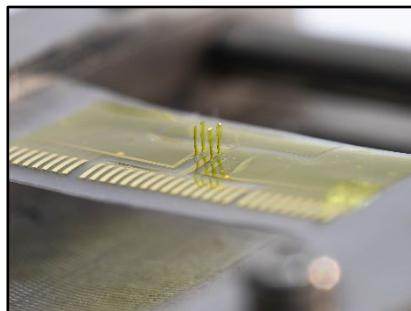
Supplementary Figure 10 | Photograph of the 3D brain mapping electrode wrapped around a glass rod with a radius of 5mm diameter

Side view

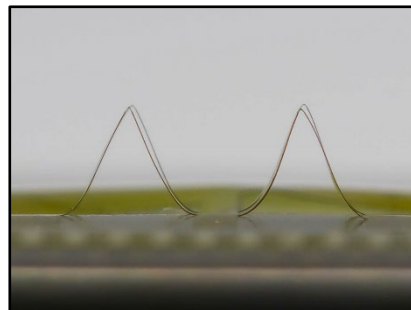
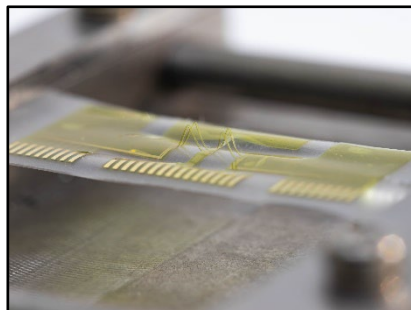
Front view

Crop image

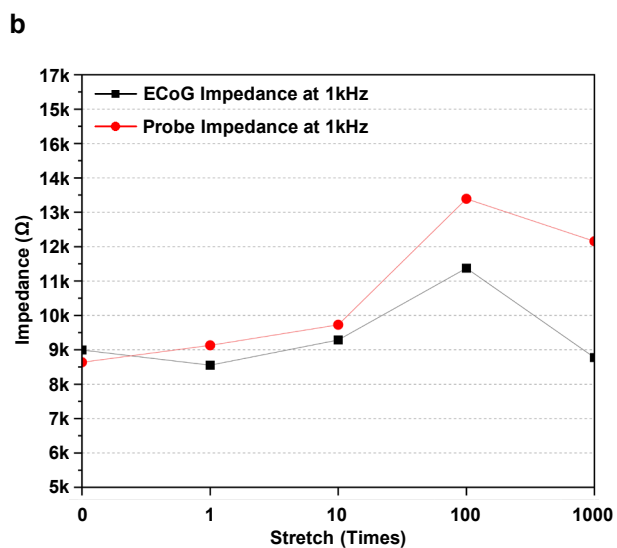
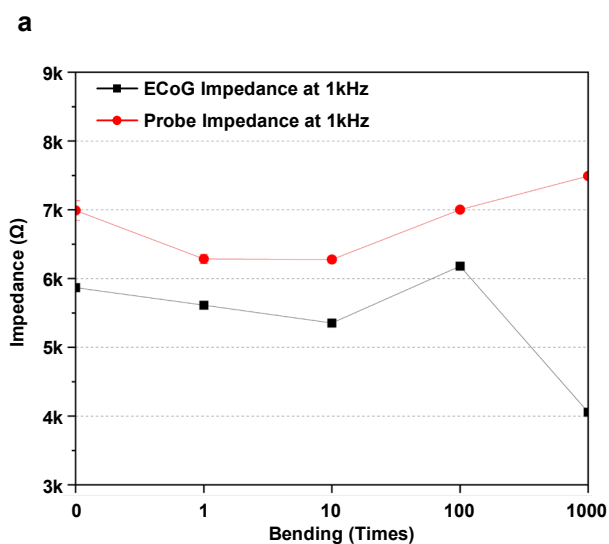
0% stretch



40% stretch



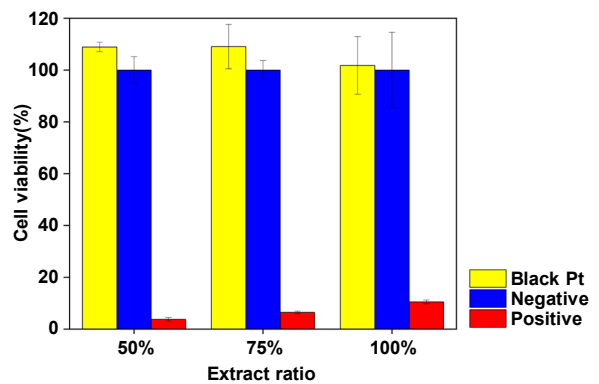
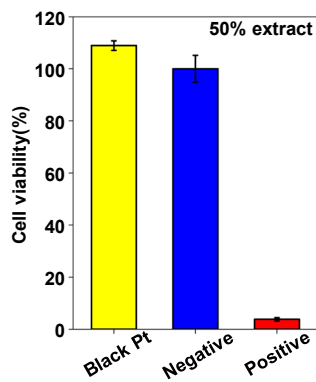
Supplementary Figure 11 | Photograph of 40% stretching test set up with the 3D brain mapping electrode



Supplementary Figure 12 | Electrochemical impedance spectra magnitude, bending and stretch test with the 3D brain mapping electrode ECoG and neural probe part.

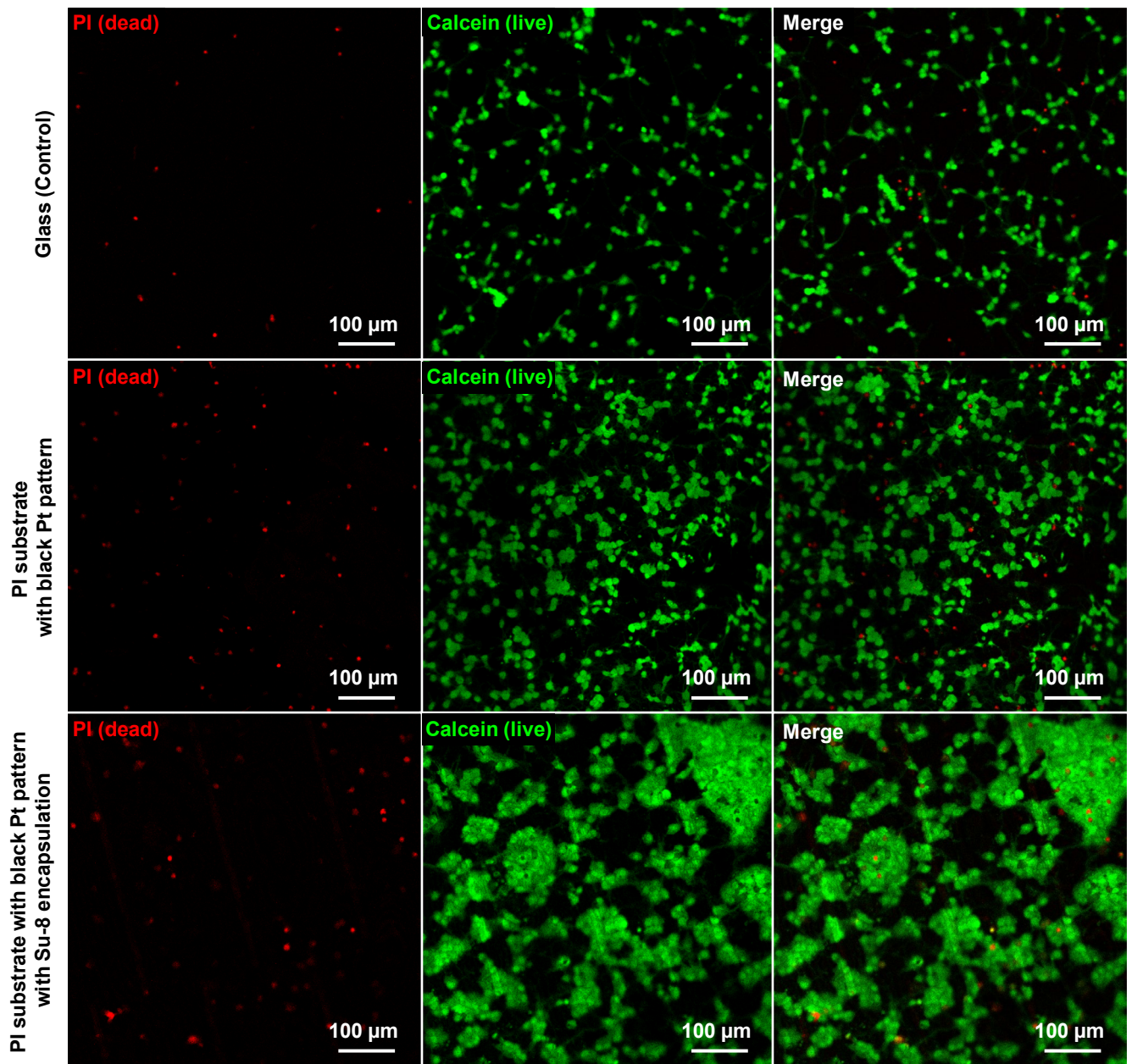
Sample	50% extract		75% extract		100% extract	
	MEAN (%)	SD (%)	MEAN (%)	SD (%)	MEAN (%)	SD (%)
Black pt	108.918	1.834731	109.0809	8.536788	101.7929	11.1461
Negative	100	5.170469	100	3.674055	100	14.55746
Positive	3.78074	0.65476	6.492543	0.498789	10.50927	0.721736

Supplementary Table 2 | Cell viability rate result with different extract ratio



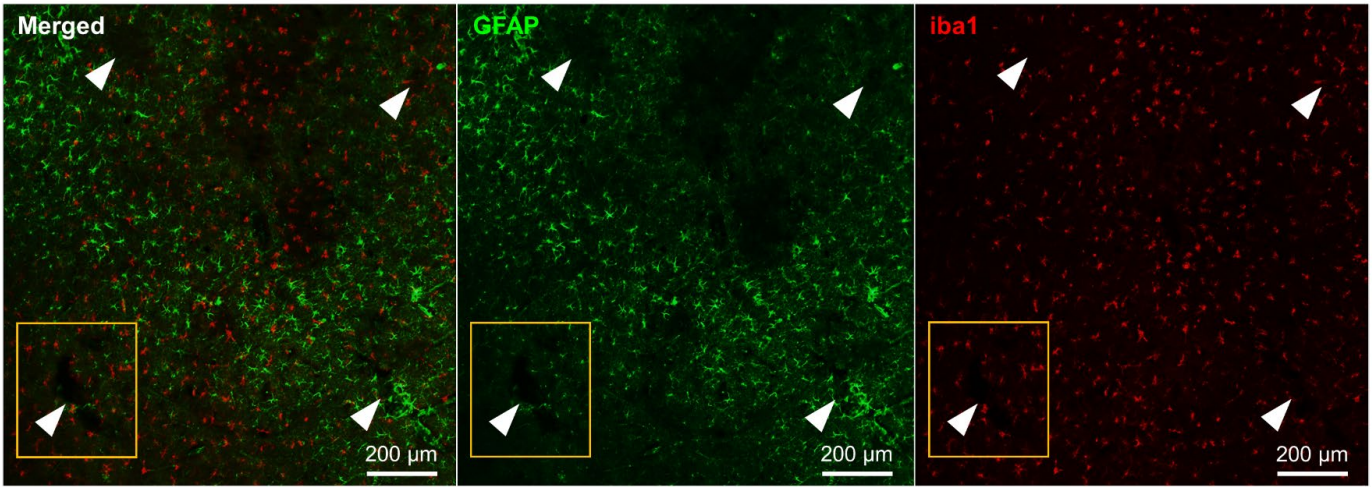
Supplementary Figure 13 | Cell viability assay for 50% extract and integrated plot with different extract ratio. Polyethylene (PE) as negative and Polyurethane (PU) as positive are used for control samples.

Day 2

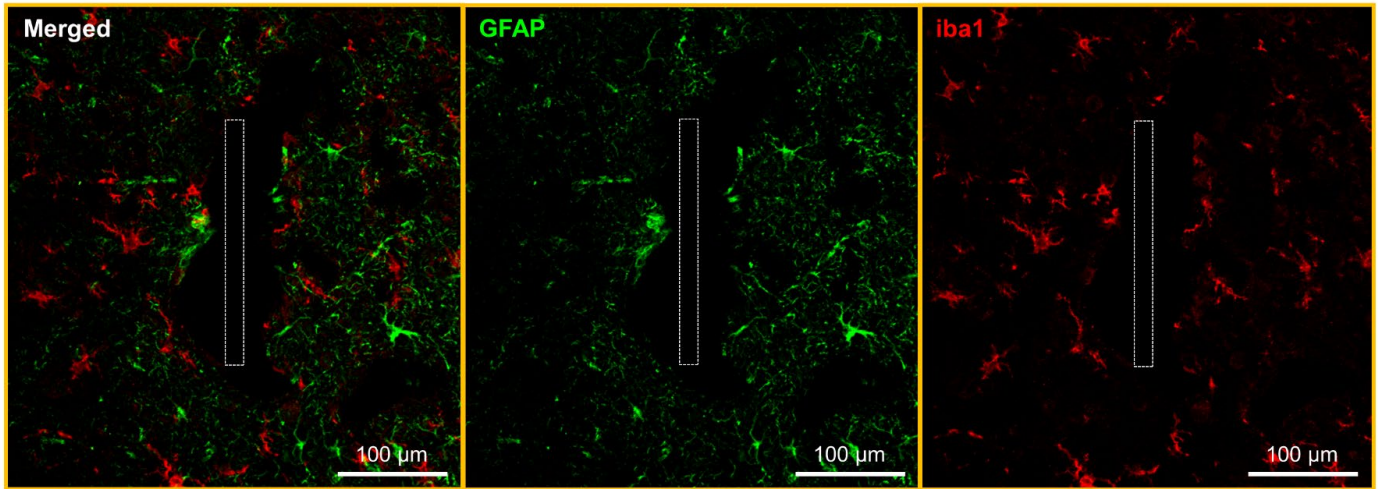


Supplementary Figure 14 | Confocal fluorescence images of live (green) and dead (red) cells stained with calcein-AM and PI on three substrates (glass substrate, PI substrate with black Pt pattern, and PI substrate with black Pt pattern with SU-8 encapsulation) at day 2 to observe the viability of the cultured neurons

a

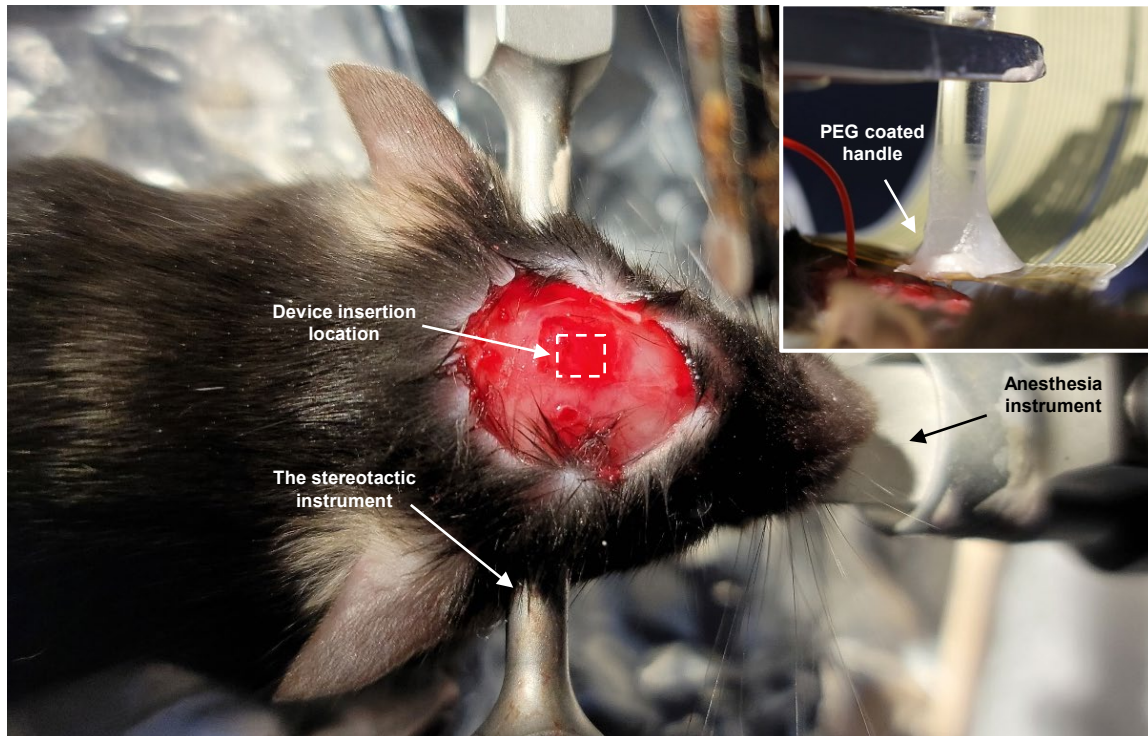


b

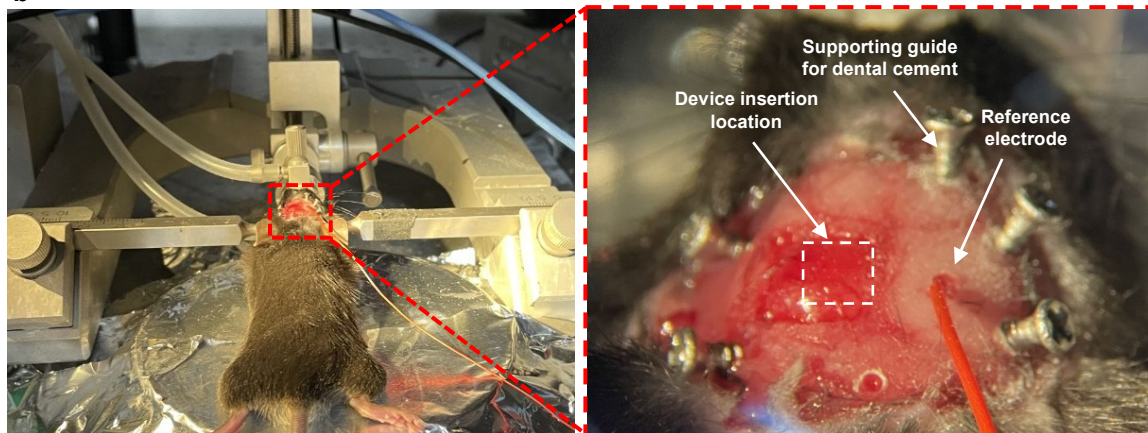


Supplementary Figure 15 | Immune response to implanted flexible 3D neural electrode array: (a) Fluorescent image and (b) expanded image (yellow box) of immunostained activated astrocyte (GFAP, green-fluorescent) and microglia (iba1, red-fluorescent) in the tissue surrounding the electrode array. The white arrow indicates where the probe was inserted. The white dotted line indicates the probe's position.

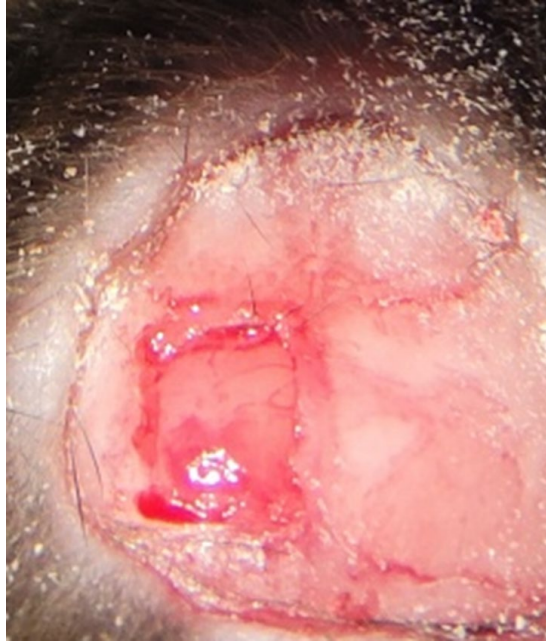
a



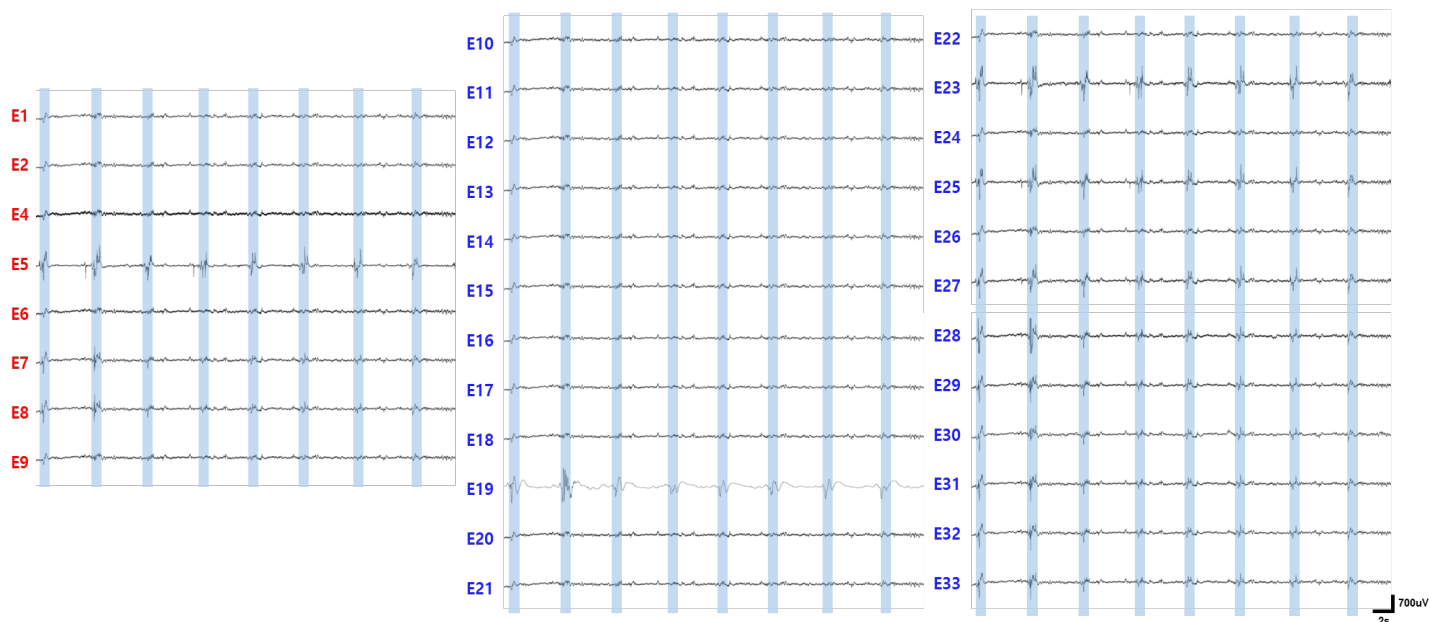
b



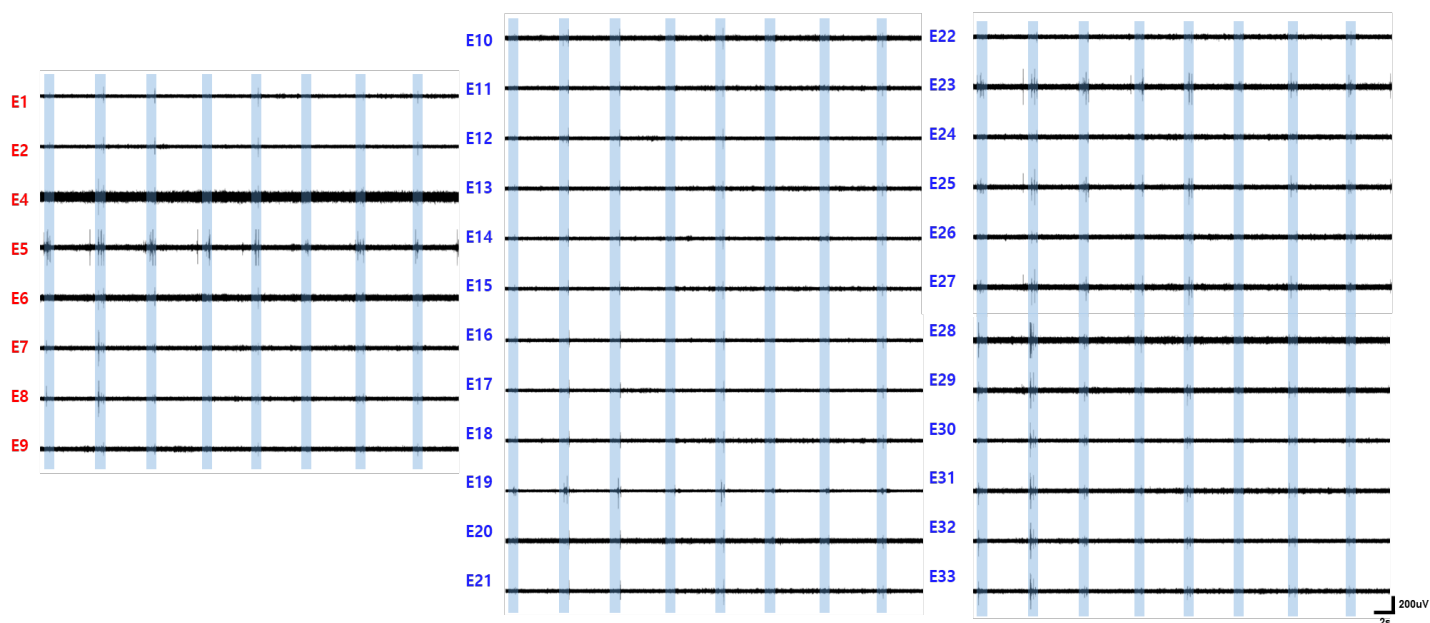
Supplementary Figure 16 | Photograph of *in vivo* experiment setup for electrophysiological signal recording inserted device location



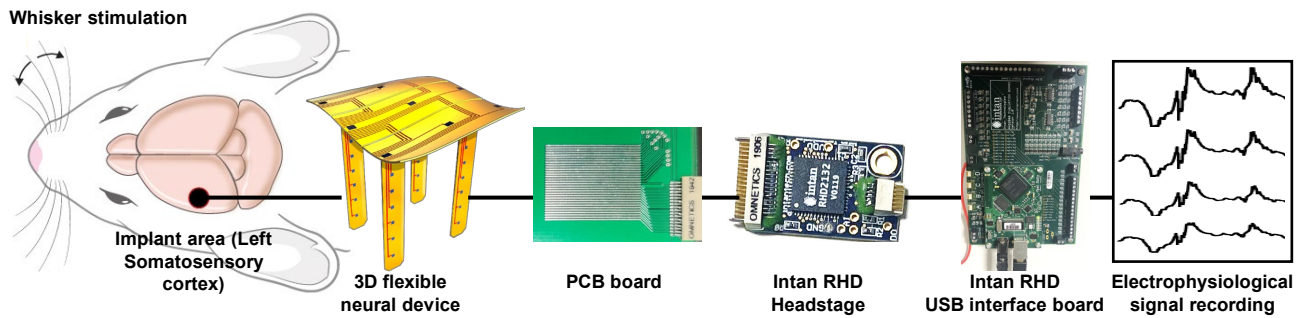
Supplementary Figure 17 | After removal of the dura mater : By wiping off the liquid with the cotton swap, there was no critical damage or bleeding.



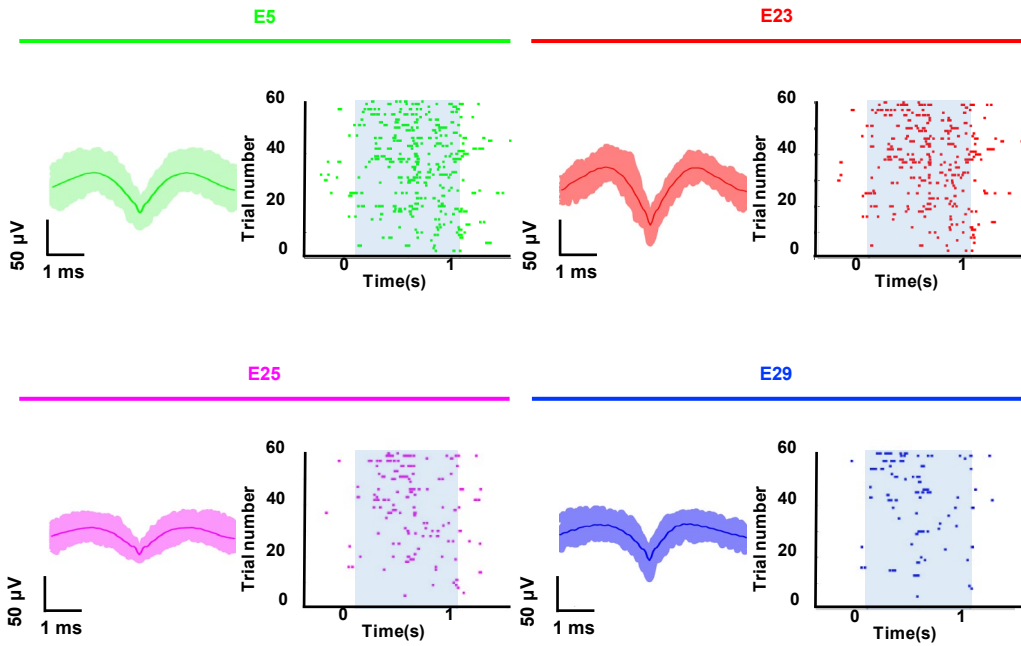
Supplementary Figure 18 | The raw LFP traces of total electrodes of the flexible 3D electrode array: The LFP signals are recorded at total electrodes for 40s (Red : Surface Electrodes Blue : internal electrodes form shank P1,P2,P3,P4 , Blue boxes: whisker stimulation).



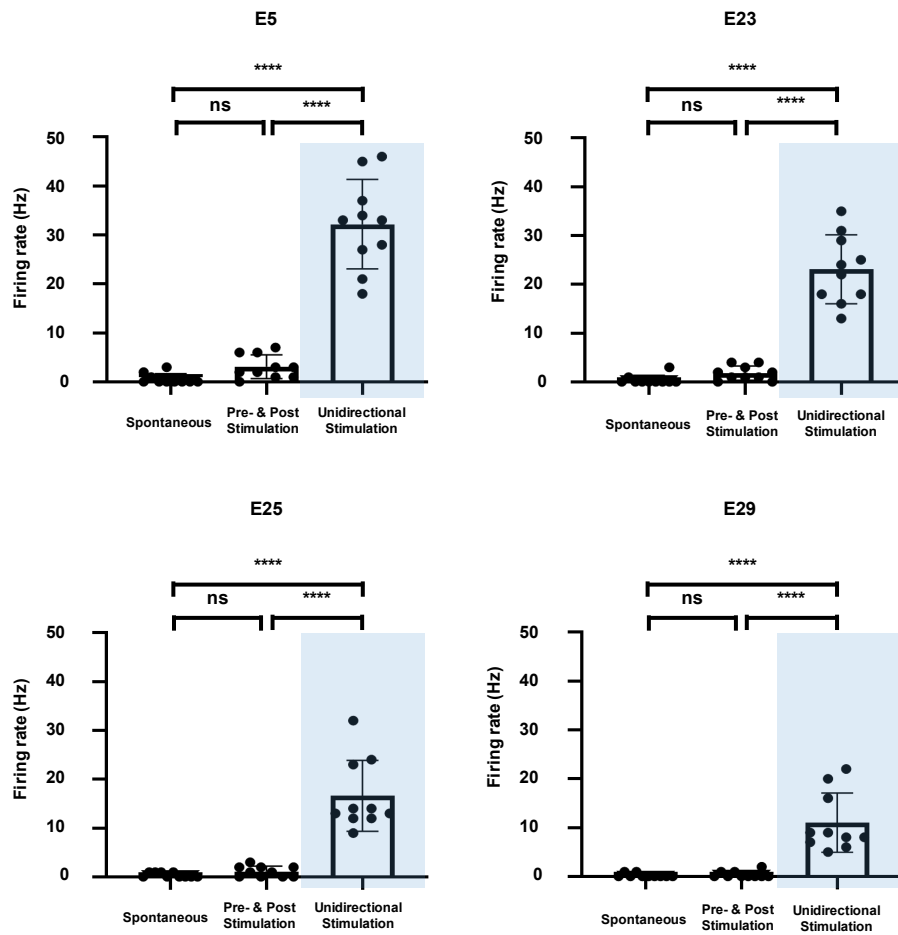
Supplementary Figure 19 | The raw neural spike traces of total electrodes of the flexible 3D electrode array: The neural spikes are recorded at total electrodes for 40s (Red : Surface Electrodes, Blue : internal electrodes form shank P1,P2,P3,P4, Blue boxes: whisker stimulation).



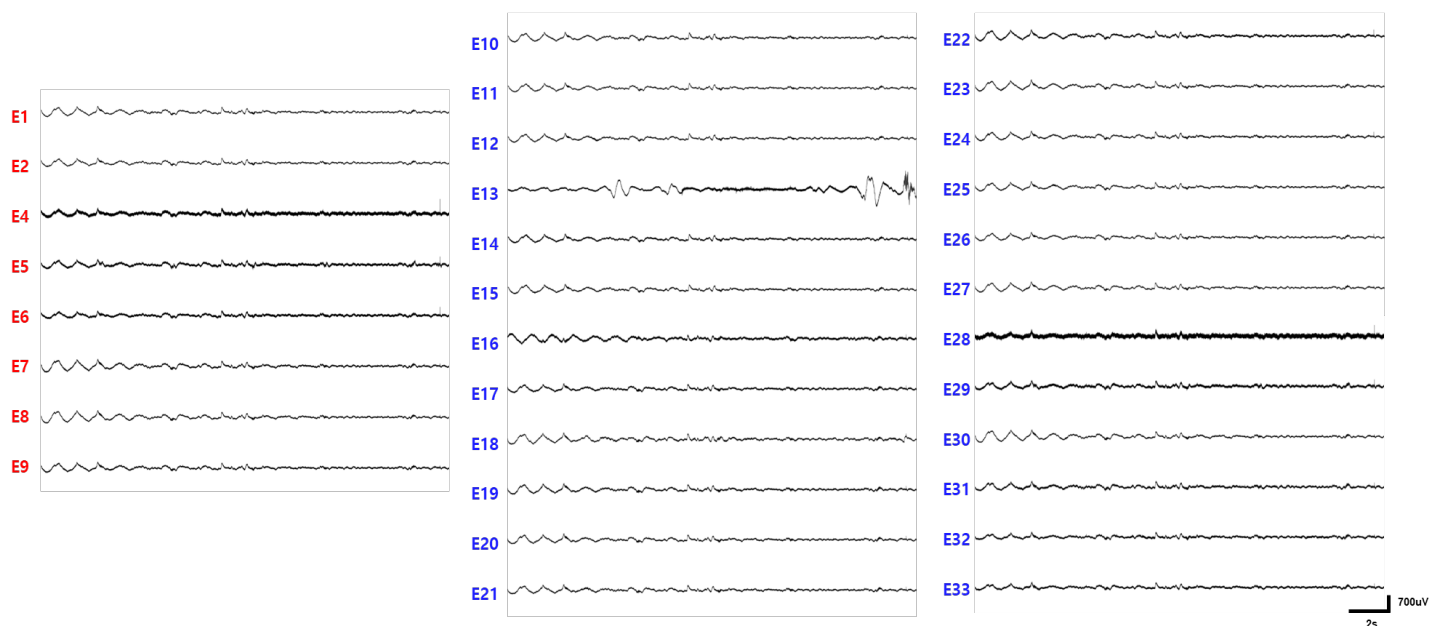
Supplementary Figure 20 | PCB & Intan RHD system setup for electrophysiological signal recording with whisker stimulation



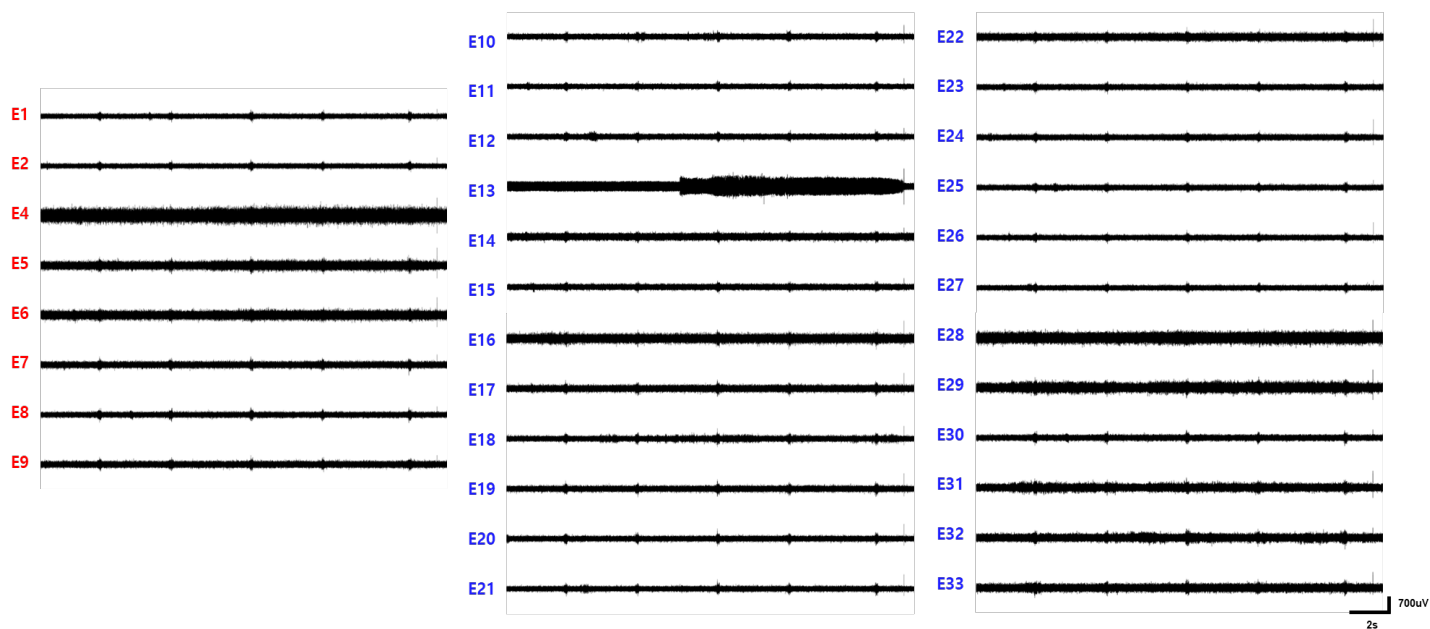
Supplementary Figure 21 | Waveforms of sorted spikes and raster plots of 60 unidirectional whisker stimulations



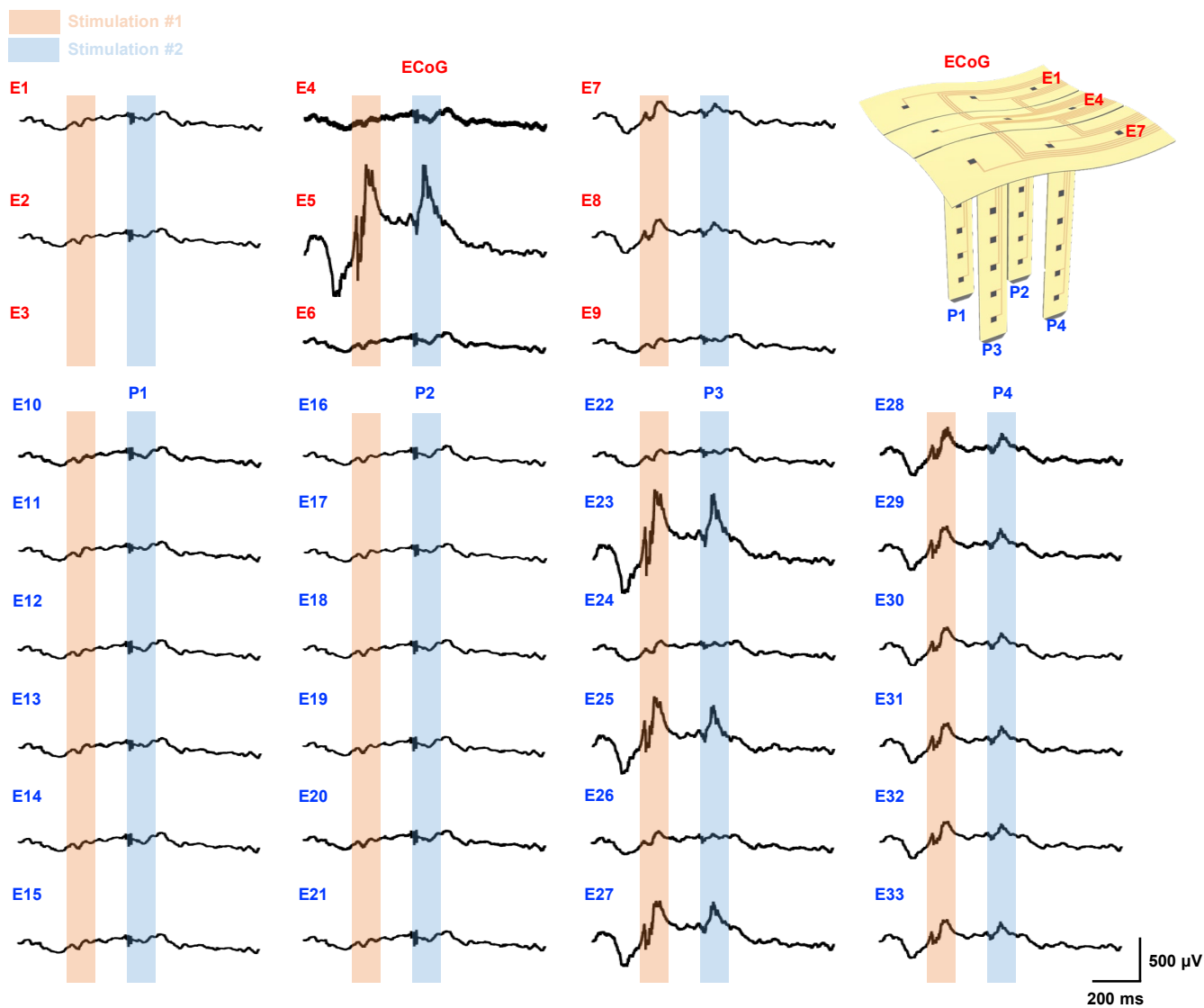
Supplementary Figure 22 | Firing rate of total detected spikes.



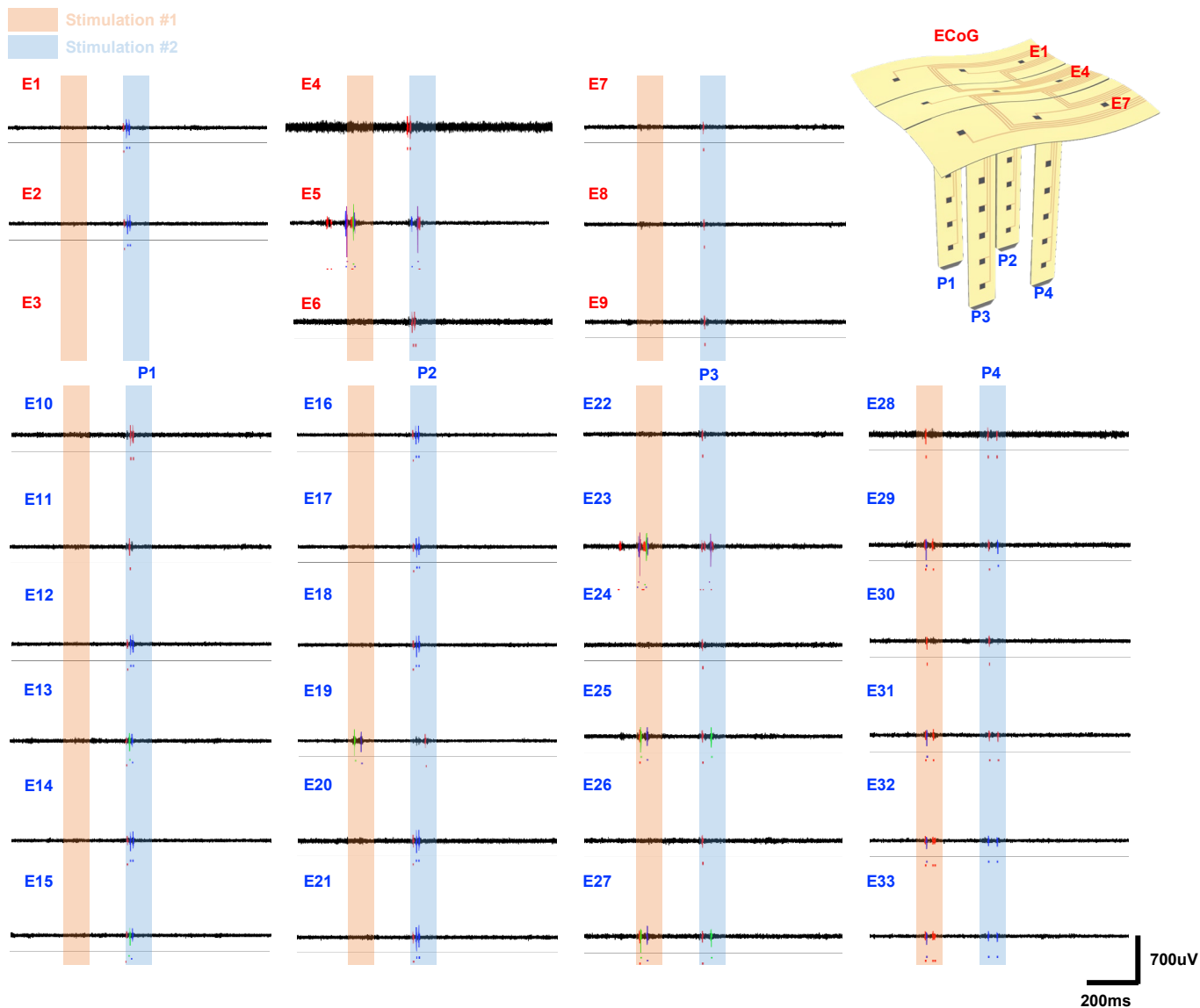
Supplementary Figure 23 | The LFP recordings without whisker stimulation of total electrodes of the flexible 3D electrode array: The LFP signals are recorded at total electrodes for 10s (Red : Surface Electrodes Blue : internal electrodes form shank P1,P2,P3,P4).



Supplementary Figure 24 | The neural spike recordings without whisker stimulation of total electrodes of the flexible 3D electrode array: The neural spikes are recorded at total electrodes for 10s (Red : Surface Electrodes, Blue : internal electrodes form shank P1,P2,P3,P4).



Supplementary Figure 25 | *In vivo* LFP data of all electrode with stimulation



Supplementary Figure 26 | *In vivo* Spike data of all electrode with stimulation