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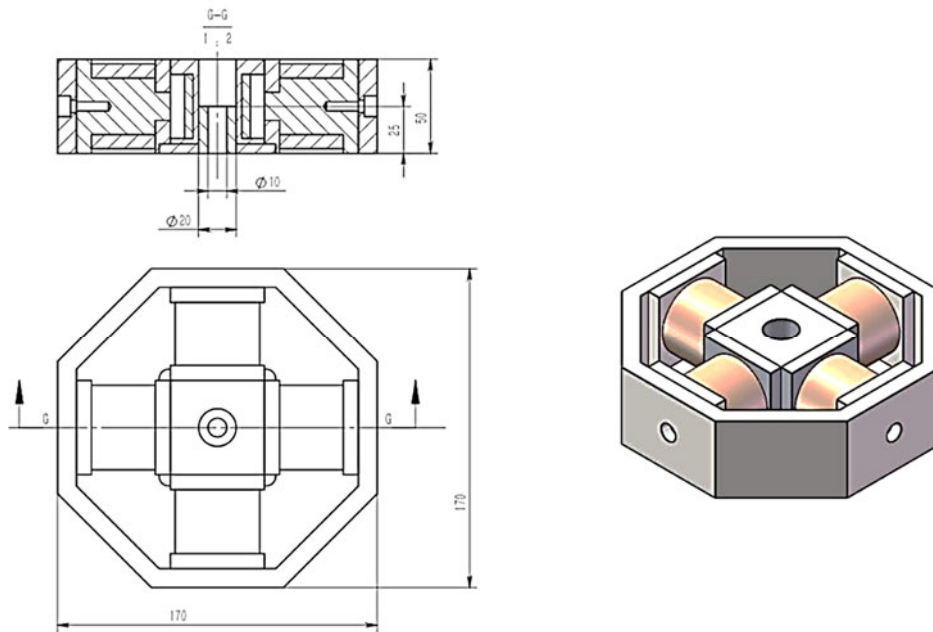
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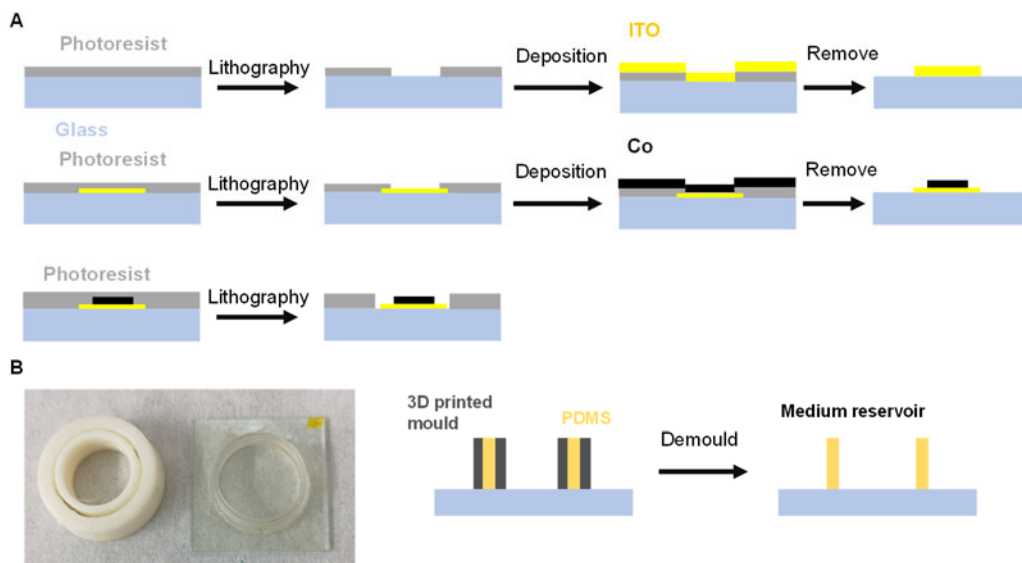
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## Supplementary information for

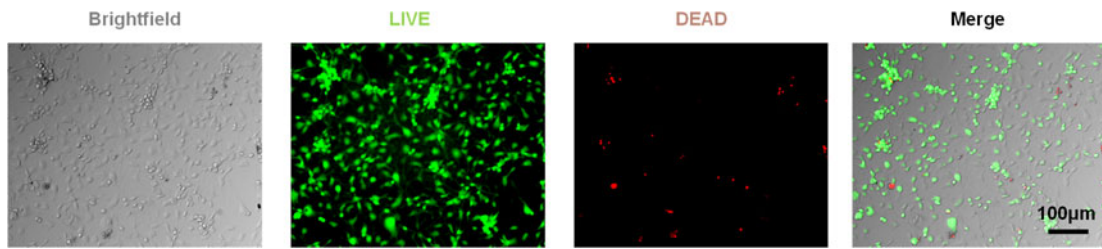
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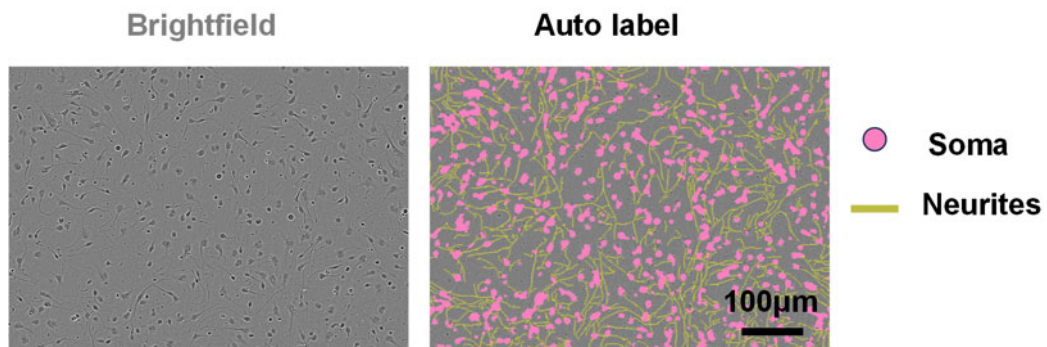
**Fig. S1** Engineering drawing of the magnetic field generator



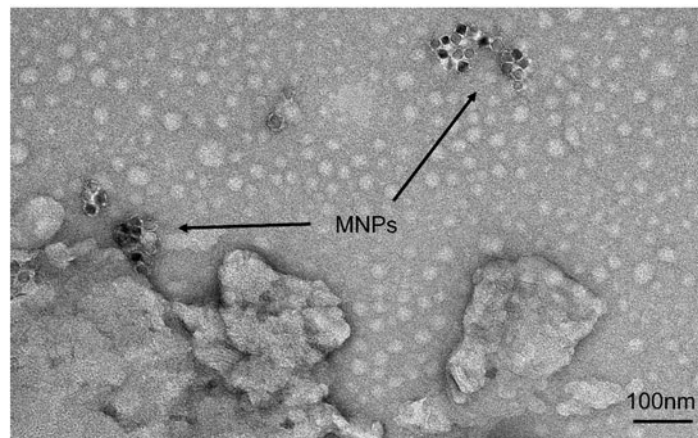
**Fig. S2** Fabrication process of MMA chip. (A) The MMA chip was fabricated by standard lithography and lift-off technique. (B) The medium reservoir was fabricated by reverse mold of PDMS



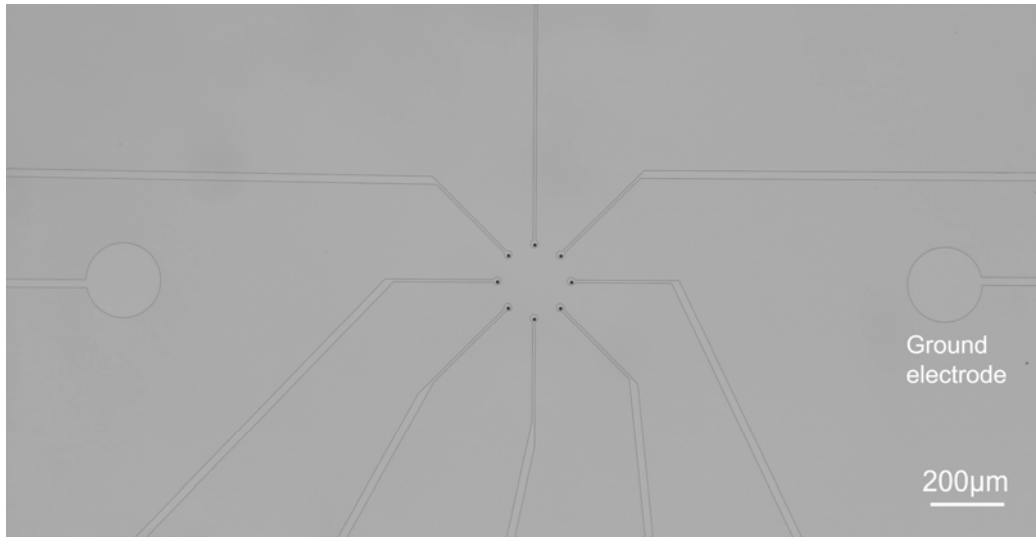
**Fig. S3** Neural viability test of neurons without MNPs by using Calcein-AM/PI staining kit



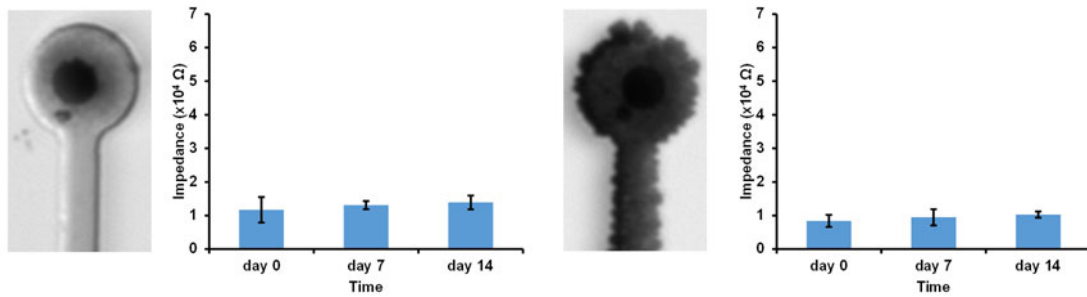
**Fig. S4** Neuromorphology test of neurons without MNPs by using Incucyte Live-Cell Analysis System



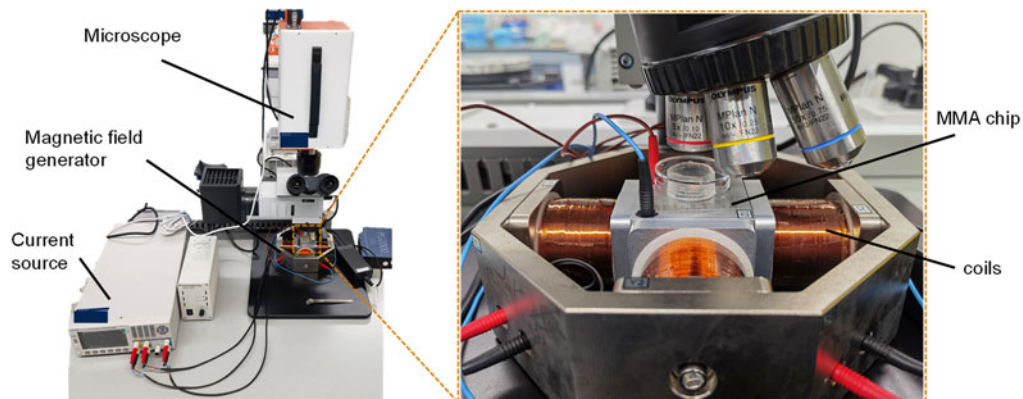
**Fig. S5** The TEM figure of MNPs, which were inside neurons for two weeks. There was some organic matter stuck to it, but the shape is still clear and stable, indicating the long-term stability of MNPs inside neurons



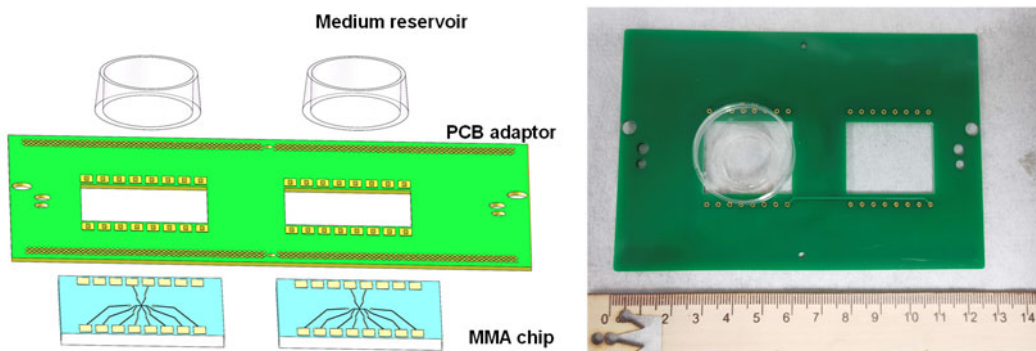
**Fig. S6** Position of two reference electrodes relative to the micromagnet circular array



**Fig. S7** Electrodes coated with PEDOT:PSS for 2 min (left) and 8 min (right) were immersed in culture medium for two weeks and the impedance still maintained in a low level. Data are expressed as mean  $\pm$  standard deviation ( $n=3$ )



**Fig. S8** A physical view of the whole MMA device during the experiments



**Fig. S9** The matched PCB was designed to connect the proposed MMA chip with the commercially available data acquisition system