2D nanomaterial-based ultrathin flexible microelectrode array for extracellular spike

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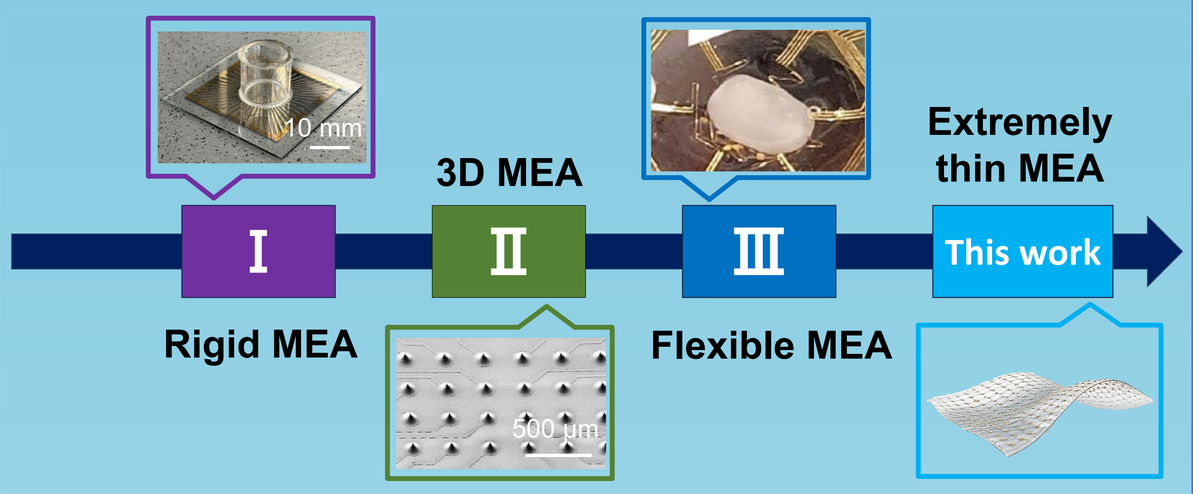
TERMIS EU-Chapter 2026 PALMA DE MALLORCA 21-24 APRIL / SPAIN

Background

Understanding diseases such as long QT syndrome requires analysis of both single-cell electrophysiological activity and synchronized activity in cell populations. There are two methods for recording the electrical activity of excitable cells. Patch-clamp recording provides precise intracellular measurements, but it requires advanced skill and high cost. In contrast, MEAs enable simultaneous extracellular recordings from multiple cells, making them suitable for network-level analysis. In this study, we used an MEA-based approach to record extracellular potentials from excitable cells.

Concept

・Evolution of MEAs and remaining challenges

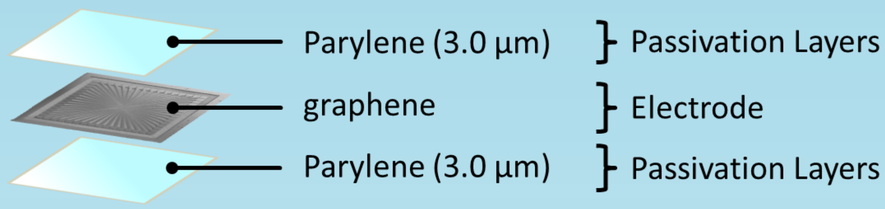


Extremely thin MEAs are particularly attractive because they can form conformal contact with cell surfaces, reducing mechanical load and improving electrical coupling.

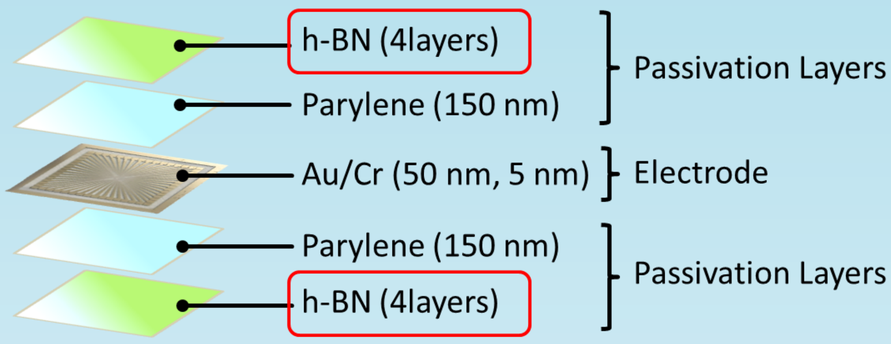
・Utilization of 2D materials in MEAs

2D materials have gained attention as a promising approach for developing MEAs that combine high flexibility with ultra-thin structures.

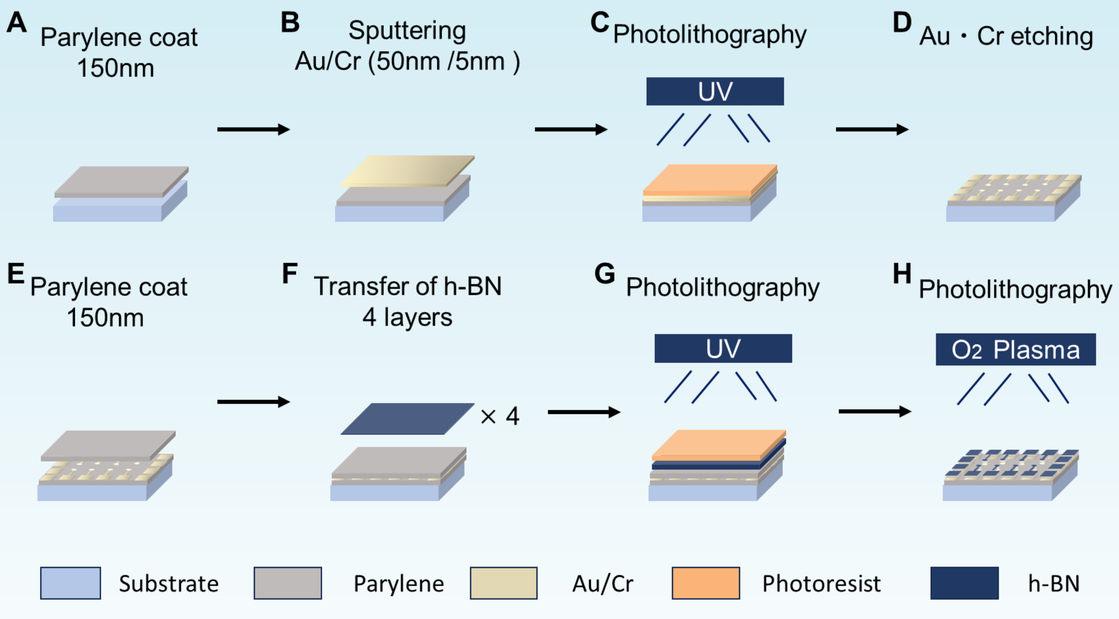
Current status
The use of 2D materials has been limited to the electrode Layer.



This work
2D materials are introduced into the passivation layer.



Fabrication Process



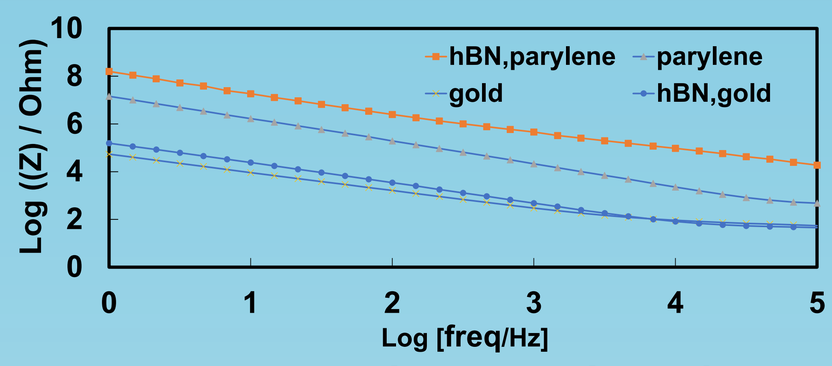
Acknowledgment
This study was supported by JASP KAKENHI (24H00890).

Results

・Electrochemical characterization of hBN-passivated MEA

Electrode impedance measurement

The impedance required for MEAs is generally considered to be 1 MΩ. The passivation performance of hBN was evaluated by comparison with electrodes fabricated from other materials.

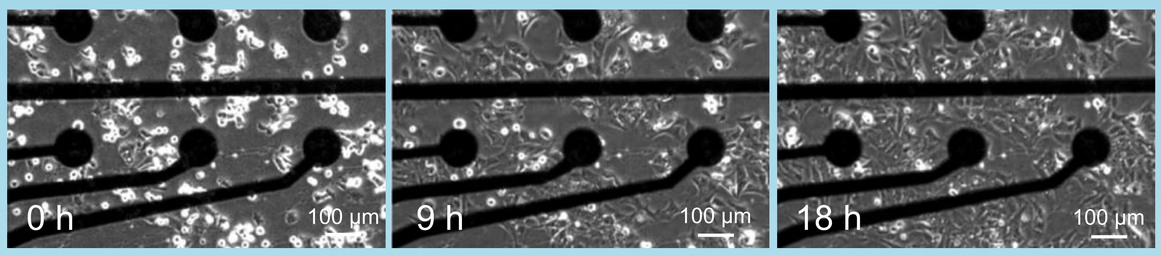


・Cell culture evaluation on the hBN-passivated MEA

HL-1 cells were cultured on a hBN-passivated MEA to evaluate the biocompatibility of h-BN. The results are shown below.

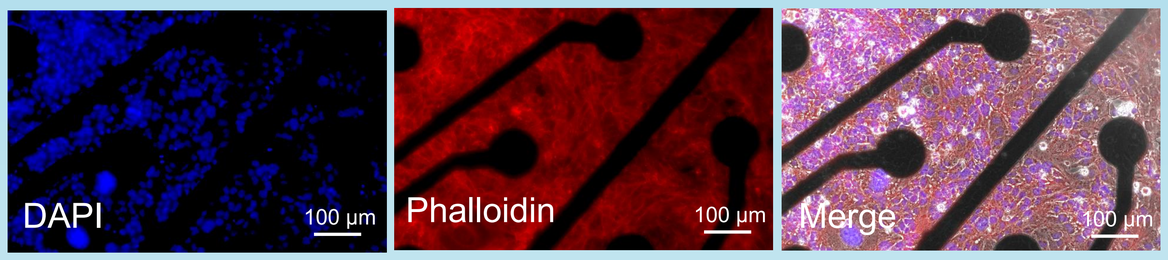
Time-lapse imaging

Time-lapse imaging every 20 s for 18 h confirmed the attachment and proliferation of HL-1 cells on a hBN-passivated MEA.



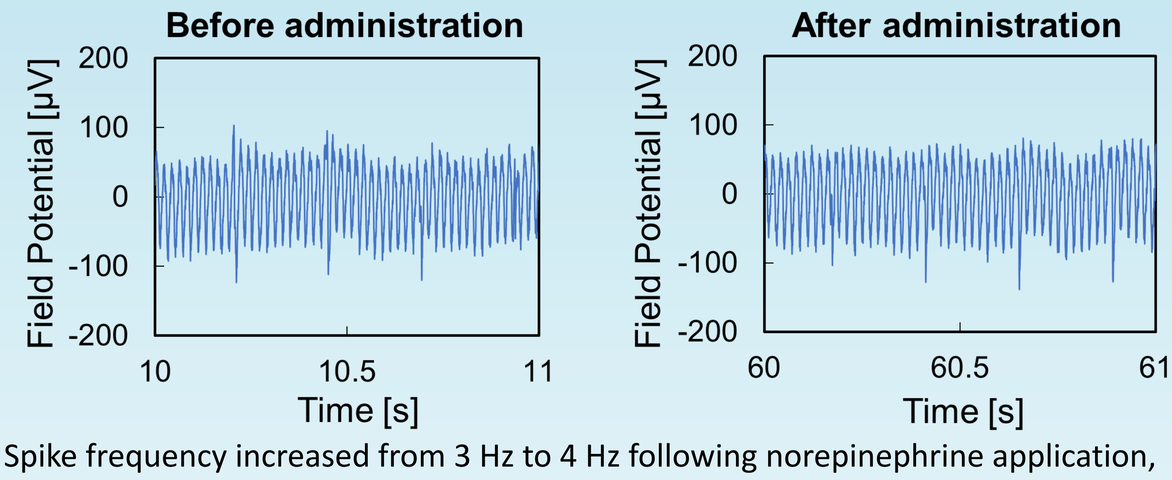
Immunofluorescence staining

DAPI and phalloidin staining visualized the nuclei and cytoskeleton, confirming healthy cell morphology on a hBN-passivated MEA.



・Spike recording of HL-1 cells cultured on a hBN-passivated MEA

To verify the cellular origin of the recorded signals, changes in spike frequency in response to norepinephrine were evaluated.



Spike frequency increased from 3 Hz to 4 Hz following norepinephrine application, confirming the cellular origin of the recorded signals. These results demonstrate successful extracellular potential recording using hBN-based electrodes.

Conclusion

- Biocompatibility of h-BN was confirmed through immunostaining and calcium imaging of HL-1 cells.
- The h-BN-based MEA successfully recorded extracellular potentials and detected changes in spike frequency following noradrenaline administration.

Contact
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