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Kirigami electronics for long-term integration and electrophysiological recording of neural organoids and assembloids

Stanford researchers have developed kirigami-inspired electronics (KiriE), flexible electronics that transition in suspension from a flat 2D pattern to a 3D basket-like configuration to seamlessly integrate with and chronically record electrical activity from 3D neural organoids and assembloids in suspension. This technology allows for long-term, non-invasive monitoring of electrical activity without disrupting the natural self-organization and development of these 3D cultures.

Traditional methods of detecting electrical activity in neural organoids involve invasive techniques like patch clamping, slicing, or using rigid electrodes, which can interfere with the development and self-organization of these structures. Additionally, existing non-invasive methods require the organoids to be in contact with a substrate, potentially affecting their growth and function. The new technology developed by Stanford researchers overcomes these challenges by employing ultra-thin kirigami-inspired electronics (KiriE) that integrate with 3D neural organoids in suspension. This system includes a multifunctional culture platform that supports long-term medium perfusion, multimodal assays, and chronic electrophysiological measurements. The KiriE patterns, specifically designed for high deformability and mechanical durability, adapt to the 3D geometry of the organoids, allowing continuous monitoring over months of development, while preserving their morphology, cytoarchitecture and cell composition.

Stage of Development
Proof of Concept

Applications

- Electrical recording from 3D multi-cellular systems in suspension
- Long-term monitoring of neural development and activity
- Study of neuropsychiatric disorders
- Large-scale drug testing platform
- Integration with various tissue systems and multi-cellular models, including cardiovascular organoids and 3D bioprinted tissue constructs
- Probing multi-synaptic transmission in complex 3D geometries

Advantages

- Non-invasive long-term recording from 3D cultures
- Does NOT interfere with 3D cytoarchitecture or development of organoids
- Enables continuous monitoring over months
- Multifunctional platform for medium perfusion, live-cell imaging, real-time electrophysiology measurements and optogenetic modulation
- High deformability and mechanical durability of KiriE patterns
- Stable integration with intact neural organoids in suspension without the need for insertion, slicing or contacting the substrate

Publications

- Yang, X., Forró, C., et al.. (2024). Kirigami electronics for long-term electrophysiological recording of human neural organoids and assembloids. Nature Biotechnology, 1-8.

Patents

- Published Application: WO2024145528

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