Hybrid Integration Method and Integrated Circuit Design for Compact, High Density, Minimally-Invasive Neural Recordings

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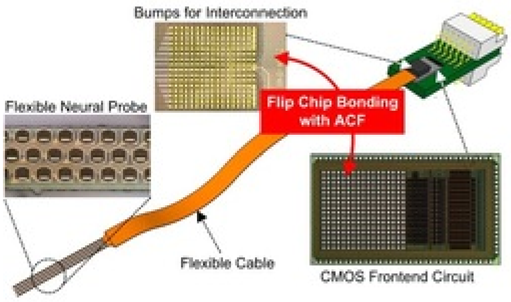

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OVERVIEW

Neural interfaces hardware enabling long-term, high channel-count neural recordings

- Compact size with significantly reduced are consumptions of interconnections
- Eliminates distortion in the recorded signals compared to conventional systems

BACKGROUND

Neural recording systems are technologies designed to capture and analyze electrical activity in the nervous system, including the brain and peripheral nerves. These systems are essential tools for neuroscientists, clinicians, and researchers studying brain function, neural circuits, and neurological disorders. Current state-of-the-art neural recording systems provide just 100-300 parallel channels and many of them use rigid silicone-based probes, which result in tissue damage. There is now a growing body of research on flexible probe geometries both from academia and early-stage startups to enable long-term, neural recordings. But, even with flexible probes, front-end Integrated Circuits (ICs) remains highly dependent on Si-based CMOS technology. This requires hybrid integration techniques for the interconnection between the probes and front-end ICs. As the number of channels increases, the size of the interconnects and hence the device can increase dramatically. There is therefore a critical need for flexible, biocompatible probes that are both compact and provide a high channel-count to enable large-scale in vivo neural recordings.

INNOVATION

Researchers at the University of Michigan have created a hybrid technology technique with the potential to drastically reduce the area consumption of the interconnection to enable long-term, high channel-count neural recordings. This reliable, hybrid integration technique combines a flexible neural probe and front-end CMOS-based integrated circuits (ICs) to achieve a compact, stable, and high channel-count neural recording device. The two key ingredients of the hybrid integration technique are: a) A low-temperature, low-pressure flip-chip bonding approach using anisotropic conductive films: Used for the interconnection between the flexible probe and front-end ICs, and b) An analog circuit-under-pads: The front-end ICs are placed entirely under the connector pads to the flexible neural probe, resulting in a dramatic area reduction. This capability is made possible due to a low-pressure flip-chip bonding technique, which prevents damage of the underlying ICs when attaching the flexible probe. The approach was used to build a 256-channel prototype with an active IC area per channel of 0.0117 mm2. The prototype also included a novel IC design, which eliminates distortion in the recorded signals compared to conventional systems.

PATENT APPLICATION

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References

1. Park SY, et al. , A Miniaturized 256-Channel Neural Recording Interface With Area-Efficient Hybrid Integration of Flexible Probes and CMOS Integrated Circuits. IEEE Transactions on Biomedical Engineering, vol. 69, no. 1, pp. 334-346, Jan. 2022, doi: 10.1109/TBME.2021.3093542.