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µECoG Array with 3,072 Electrodes for High-Density and Large-Area Cortical Recordings Based on Scalable Thin-Film Electronics

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Introduction: Large-scale neural implants, involving hundreds of electrodes and spanning multiple cortical areas, are emerging in clinics and neuroscience laboratories [1][2], however their accessibility remains limited. These technologies are based on cutting-edge flexible materials and rely on advanced integrated circuits for their acquisition, and therefore are only produced in research environments at high costs. We propose a novel system, including an industrially manufactured multi-thousand channel µECoG implant, and a commercially available acquisition tool, resulting in a full neural implant solution, easily integrated in any laboratory environment.

Material, Methods and Results: Our µECoG can simultaneously record neural signals in the 1-200 Hz ECoG bandwidth, with 3,072 multiplexed electrodes. The embedded metal-oxide thin-film transistors used to switch between electrodes have previously been established by our group [3], and are now being manufactured in an industrial foundry. Moreover, we have shown their biocompatibility according to ISO standards [3]. Their new low-cost and rapid production yields scaled devices, optimized for high conformability to the brain tissue with an 18 µm thick polyimide substrate. High resolution and very high-density is achieved through iridium electrodes with 200 µm pitch and customizable size between 30*30 and 100*100 µm². We have developed a small headstage and flexible connectors which enable a smooth implantation of the devices. Interfacing printed circuit boards (PCBs) were designed to achieve a compact system connecting to a carefully selected standard acquisition tool for electrophysiology laboratories. Demultiplexing of the signals is performed in near real-time enabling monitoring of the signals during recordings. In-vivo experiments have shown the capability of the implant to delineate whisker movements in the somatosensory cortex of rodents and has revealed dynamics across several cortical areas.

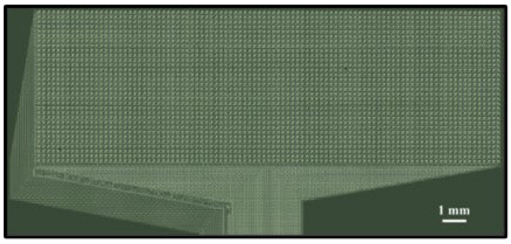

Figure 1: *Micrograph of the 3,072 electrode µECoG implant with 100×100 µm² iridium electrodes and 200 µm electrode pitch.*

Conclusion: The accessible µECoG system developed in this work yields unparalleled high-density recordings over large areas of the cortex. Thanks to its industrial production, the number of electrodes could be drastically increased compared to state-of-the-art implants and enables the rapid and low-cost manufacturing of the devices. Multi-thousand channel implants thus become easily accessible and can help push the boundaries of neuroprostheses.

References:
[1] Benabid AL, et al. An Exoskeleton Controlled by an Epidural Wireless Brain–Machine Interface in a Tetraplegic Patient: A Proof-of-Concept Demonstration. In *The Lancet Neurology 18,* no. 12: 1112–22, 2019.

[2] Moses DA, et al. Neuroprosthesis for Decoding Speech in a Paralyzed Person with Anarthria. In *New England Journal of Medicine 385*, no. 3, 2021.

[3] Londoño-Ramírez H, Huang X, Cools J, Chrzanowska A, Brunner C, Ballini M, Hoffman L, Steudel S, Rolin C, Mora Lopez C, Genoe J, Haesler S. Multiplexed Surface Electrode Arrays Based on Metal Oxide Thin-Film Electronics for High-Resolution Cortical Mapping. In *Advanced Science*, 11, 2308507, 2024.

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