Brain–computer interfaces

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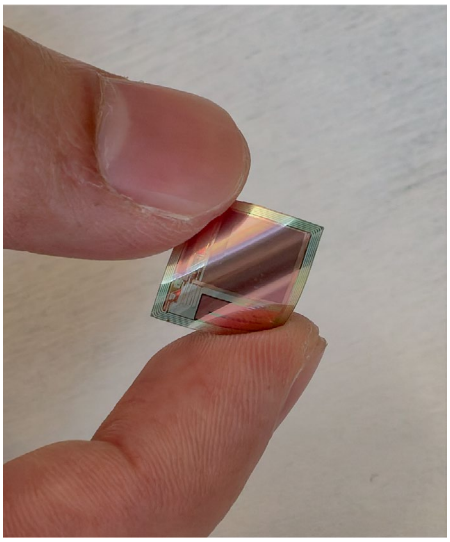
Integrated µECoG–CMOS system enables high-density neural recording



In the field of neural electrophysiology, traditional methods like electroencephalography are non-invasive but offer limited resolution, while penetrating electrodes provide detailed spiking data but can damage brain tissue. Electrocorticography (ECoG) presents a middle ground, using non-penetrating electrodes on the brain's surface to capture high-quality local-field-potential signals without cortical damage, yet integrating these electrodes with necessary electronics remains a hurdle. Now, writing in *Nature Electronics*, Kenneth L. Shepard and colleagues present a bioelectronic interface system to the cortex (BISC) that integrates a high-resolution micro-electrocorticography (µECoG) electrode array with wireless electronics on a single chip.

"To do this, the BISC incorporates all the functions of the device integrating the µECoG array with front-end analog electronics, data conversion, digital control, wireless powering and communication capabilities," says the author. This integration is achieved on a single complementary metal–oxide–semiconductor (CMOS) substrate comprising front-end circuitry for signal amplification and filtering, a back-end analog-to-digital converter, and programmable stimulation capabilities. The 7.2 mm^3 chip — powered wirelessly by a relay station positioned outside the skin, which also facilitates data transmission — measures just 50 µm in thickness. Thinned to be mechanically flexible, it can be placed in the subdural space directly on the brain surface, minimizing tissue damage. 65,536 recording sites arranged as a 256 × 256 grid secure the simultaneous stable, high-quality recording of thousands of channels, with the ability to digitize and transmit data from a programmable subset of electrodes (256 channels at 33.9 kilosamples per second or 1,024 channels at 8.475 kilosamples per second). "We achieve a volumetric efficiency, defined as the number of simultaneously recording channels per unit implant volume and a key metric for implantable brain–computer interfaces, of over 100 channels per mm^3, vastly exceeding other devices," continues Shepard.

In vivo experiments on porcine and non-human primate models, carried out for up to several months, demonstrate the BISC's ability to capture complex neural signals and decode sensory, motor, and visual information accurately. The modular design enables scalability and adaptability to various applications, potentially transforming brain–computer interface technologies. "We have now begun intra-operative testing in human patients and have started the process with the FDA to get approval for chronic human use for motor, speech, and vision applications," concludes the author.

Silvia Conti
Nature Sensors

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