Unravelling the mind-body connection with power-efficient IC chip

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Despite the advances in neuroscience research, the human brain remains a complex puzzle with questions unanswered about how it controls human behaviour, cognitive functions and movements. Scientists from A*STAR Institute of Microelectronics, Nanyang Technological University and National University of Singapore have jointly developed and demonstrated an integrated circuit (IC) chip with record-low power consumption for direct recording of brain activities. This breakthrough minimises the patient's exposure to electromagnetic radiation and heat during the recording process, making it possible to integrate greater number of channels (>100 channels) to acquire more comprehensive profile of brain signals, paving the way to unlock the mystery behind the complex mind-body connection.

Neural recording system is a vital tool to acquire and process brain signals, and is also applied in artificial limb control (or neural prosthesis) treatments for paralyzed patients. The system comprises multiple electrodes for data acquisition and is implanted within the skull during the operation. The implantability of the system places tight limits on its size and power consumption, while at the same time demanding sufficient performance to record good quality data.

The joint team from IME, NTU and NUS demonstrated for the first time a 100-channel neural-recording IC which has a record low power consumption of 0.94 mW per channel and the ability to deliver high quality signal recording. Compared to current state-of-the-art neural recording ICs, the new Singapore-developed IC can operate at just 0.45

V supply voltage, half of what is typically required to achieve similar performance. The new 100-channel IC chip has also successfully recorded the neural signals of an anesthetized Sprague-Dawley rat, bringing the innovation a step closer to clinical deployment.

Dr Je Minkyu, Deputy Director of the Integrated Circuits and Systems Laboratory at IME, commented, "The breakthrough is made possible using an innovative multi-supply-voltage scheme and dynamic-range folding approach in the circuit architecture to achieve low-voltage, low power consumption without trading off high performance data acquisition."

"To realise a fully implantable neural recording system, we are also working with other departments on the neural probe design and materials, as well as the incorporation of drug delivery capability."

Professor Dim-Lee Kwong, Executive Director of IME, said, "The outcome of the partnership presents tremendous potential to advance neuroscience research and to restore functions of brain-injured patients. We expect IME's expertise in circuit design, sensor research, advanced packaging, and deep capabilities in fabrication know-how to contribute strongly in this application space."

Assistant Professor Yuanjin Zheng, Programme Director, VIRTUS IC Design Center of Excellence at NTU, said, "Being able to develop a power efficient chip which can record multi-channel neural signals simultaneously is a testament to NTU's deep expertise and vast experience in designing integrated circuits. NTU is also well-known for engaging in interdisciplinary research especially in the areas of Innovation and Future Healthcare, which we leveraged upon to help bridge the gap between neural science research and clinical applications."

Associate Professor Gavin Dawe from Department of Pharmacology, Yong Loo Lin School of Medicine, National University of Singapore and Singapore Institute for Neurotechnology (SINAPSE), said "As experts in neurophysiology our group at NUS worked closely with the rest of the team from IME and NTU to complete preclinical tests on the performance of the device recording neuronal activity in living brain tissue. This power-efficient yet high performance device for recording neural signals will enable new possibilities for development of implantable brain interfaces allowing paralyzed patients to control wheel chairs or robotic arms with their minds."

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