Team presents brain-inspired, highly scalable neuromorphic hardware

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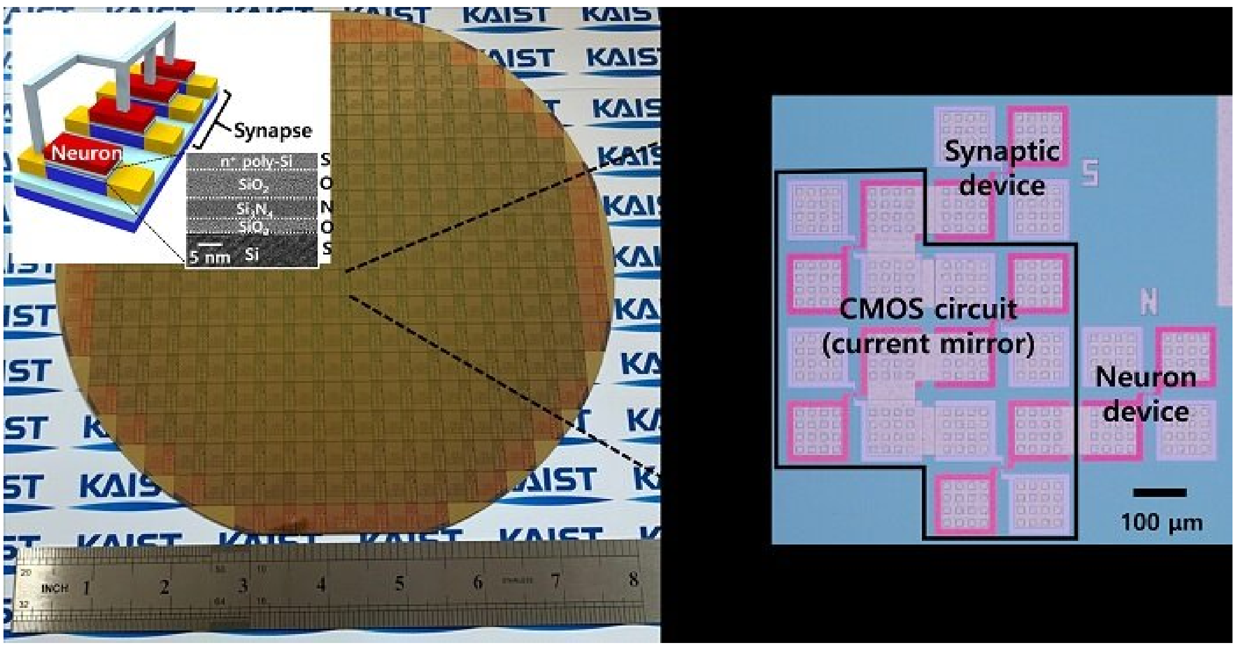

Single transistor neurons and synapses fabricated using a standard silicon CMOS process. They are co-integrated on the same 8-inch wafer. Credit: The Korea Advanced Institute of Science and Technology (KAIST)

KAIST researchers fabricated a brain-inspired highly scalable neuromorphic hardware by co-integrating single transistor neurons and synapses. Using standard silicon complementary metal-oxide-semiconductor (CMOS) technology, the neuromorphic hardware is expected to reduce chip cost and simplify fabrication procedures.

The research team led by Yang-Kyu Choi and Sung-Yool Choi produced a neurons and synapses based on single transistor for highly scalable neuromorphic hardware and showed the ability to recognize text and face images. This research was featured in Science Advances on August 4.

Neuromorphic hardware has attracted a great deal of attention because of its artificial intelligence functions, but consuming ultra-low power of less than 20 watts by mimicking the human brain. To make neuromorphic hardware work, a neuron that generates a spike when integrating a certain signal, and a synapse remembering the connection between two neurons are necessary, just like the biological brain. However, since neurons and synapses constructed on digital or analog circuits occupy a large space, there is a limit in terms of hardware efficiency and costs. Since the human brain consists of about 10^{11} neurons and 10^{14} synapses, it is necessary to improve the hardware cost in order to apply it to mobile and IoT devices.

To solve the problem, the research team mimicked the behavior of biological neurons and synapses with a single transistor, and co-integrated them onto an 8-inch wafer. The manufactured neuromorphic transistors have the same structure as the transistors for memory and logic that are currently mass-produced. In addition, the neuromorphic transistors proved for the first time that they can be implemented with a "Janus structure' that functions as both neuron and synapse, just like coins have heads and tails.

Professor Yang-Kyu Choi said that this work can dramatically reduce the hardware cost by replacing the neurons and synapses that were based on complex digital and analog circuits with a single transistor. "We have demonstrated that neurons and synapses can be implemented using a single transistor," said Joon-Kyu Han, the first author. "By co-integrating single transistor neurons and synapses on the same wafer using a standard CMOS process, the hardware cost of the neuromorphic hardware has been improved, which will accelerate the commercialization of neuromorphic hardware," Han added.This research was supported by the National Research Foundation (NRF) and IC Design Education Center (IDEC).

More information: Joon-Kyu Han et al, Cointegration of single-transistor neurons and synapses by nanoscale CMOS fabrication for highly scalable neuromorphic hardware, *Science Advances* (2021). DOI: 10.1126/sciadv.abg8836

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