Artificial synaptic device simulates the function of the human brain

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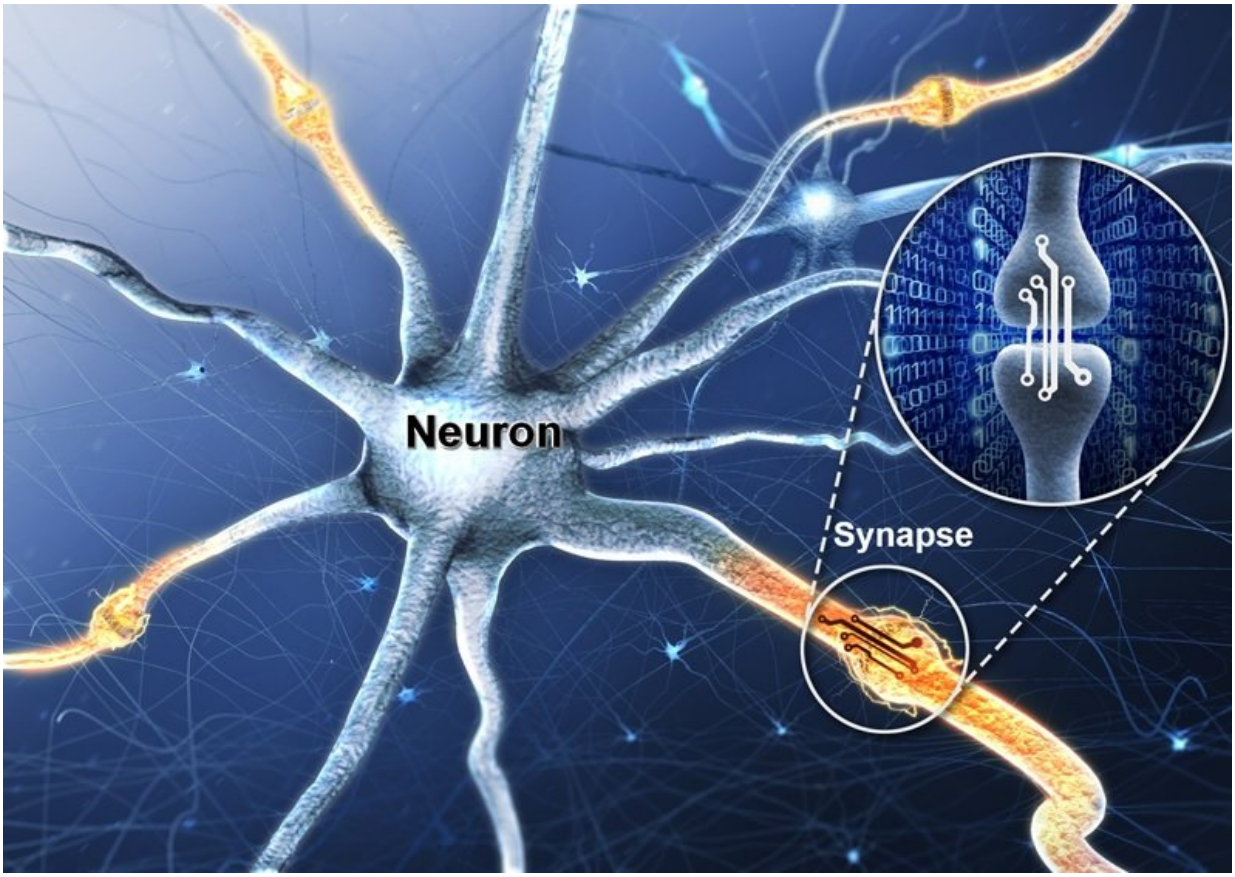

Representation of neurons and synapses in the human brain. The magnified synapse represents the portion mimicked using solid-state devices. Credit: Daegu Gyeongbuk Institute of Science and Technology(DGIST)

A research team led by Director Myoung-Jae Lee from the Intelligent

Devices and Systems Research Group at DGIST has succeeded in developing an artificial synaptic device that mimics the function of the nerve cells (neurons) and synapses that are responsible for memory in human brains.

Synapses are the meeting points of axons and dendrites that allow neurons in the human brain to send and receive nerve signals; there are known to be hundreds of trillions of synapses in the human brain. Dr. Lee's research team, along with their collaborators, have developed a high-reliability artificial synaptic device with multiple values by structuring tantalum oxide—a trans-metallic material—into two layers of Ta_2O_{5-x} and TaO_{2-x} and by controlling its surface.

The artificial synaptic device developed by the research team is an electrical synaptic device that simulates the function of synapses in the brain as the resistance of the tantalum oxide layer gradually increases or decreases depending on the strength of the electric signals. It has overcome durability limitations of current devices by allowing current control on a single layer of Ta_2O_{5-x}.

In addition, the research team successfully implemented an experiment that realized synapse plasticity, which is the process of creating, storing, and deleting memories, such as long-term strengthening or suppression of memory deletion by adjusting the strength of the synapse connection between neurons.

The non-volatile multiple-value data storage device has a small footprint, reducing circuit connection complexity, and reducing power consumption by more than 1000 compared to data storage methods based on digital signals using zeros and ones, such as volatile CMOS memory.

The high-reliability artificial synaptic device developed by the research

team can be used in ultra-low-power devices or circuits for processing massive amounts of data due to its capability of low-power parallel arithmetic. It has applications in next-generation intelligent semiconductor device technologies such as artificial intelligence (AI), machine learning and deep learning and brain-mimicking semiconductors.

Dr. Lee said, "This research secured the reliability of existing artificial synaptic devices and improved the areas pointed out as disadvantages. We expect to contribute to the development of AI based on the neuromorphic system that mimics the human brain by creating a circuit that imitates the function of neurons."

More information: Myoung-Jae Lee et al, Reliable Multivalued Conductance States in TaOx Memristors through Oxygen Plasma-Assisted Electrode Deposition with in Situ-Biased Conductance State Transmission Electron Microscopy Analysis, *ACS Applied Materials & Interfaces* (2018). DOI: 10.1021/acsami.8b09046

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