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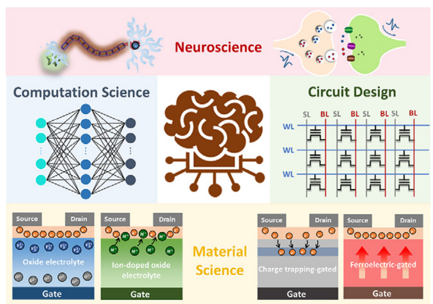
A survey of oxide-based three-terminal artificial synapses for physical neural network applications



In the 1980s, renowned scientist Carver Mead pioneered biologic-inspired “neuromorphic engineering,” which involves large-scale integration systems with electronic analog circuits that mimic neurobiology.

Since then, computing power requirements have exponentially increased with the demand for massive parallelism and cognitive operations, and separated memory and central processing units in conventional architecture have led to insurmountable speed barriers. This has compelled the investigation of alternative hardware architectures and devices that can meet the energy efficiency requirements for neuromorphic computing.

“It is an urgent imperative to construct an efficient brain-inspired physical neural network for hardware implementation,” said author Jen-Sue Chen.

Chen and Chen explored advances in oxide-based three-terminal artificial synapses for physical neural network applications, surveying research on emerging synaptic transistors fabricated with both oxide semiconductor channels and oxide dielectrics. Based on the charge relocation in dielectrics for gating channel conductance, the authors classified and discussed four types of devices: oxide electrolyte-gated transistors, ion-doped oxide electrolyte-gated transistors, ferroelectric-gated transistors, and charge trapping-gated transistors.

“This represents the first research that explores these fundamental physical mechanisms, which will benefit the reliability and yield of the synaptic devices,” said Chen.

The authors discussed both performance improvements and limitations of oxide-based synaptic transistors, specified the deployment of circuitry and algorithms for their neural networks, and outlined possible goals and directions of future research.

“To advance the field of neuromorphic hardware, the integration of multiple disciplines including materials science, peripheral circuitry, computation science and neuroscience must be further explored,” said Chen.

Source: “Perspective on oxide-based three-terminal artificial synapses in physical neural networks,” by Kuan-Ting Chen and Jen-Sue Chen, Applied Physics Letters (2022). The article can be accessed at https://doi.org/10.1063/5.0115449.