Neuromorphic Functions Achieved by Atomic Switches

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In developments of neuromorphic systems, functions such as a synaptic function have been emulated by a circuit consisting of CMOS devices and analog devices, limiting the large-scale integration of neuromorphic functions. Recently, various nonvolatile memories, such as PCMs, ReRAMs, and FeRAMs, have achieved synaptic functions by a single device, enabling a large-scale integration of nueromorphic functions.

Atomic switch is one of the nonvolatile memories, which is operated by controlling formation/annihilation of a metal filament using solid electrochemical reactions [1]. Among various atomic switches, a gap-type atomic switch shows unique neuromorphic functions because of its unique operation mechanism. That is, multiple phenomena occur in the operation of a gap-type atomic switch. Namely, diffusion of metal cations in a solid electrolyte such as Ag2S, their reduction/oxidation processes at a surface, diffusion of precipitated metal atoms on a surface. This multiplicity enables learning based on sensory, short-term, long-term memorization depending on the frequency of input pulses [2], which is observed in human brain when learning something.

Since the synaptic weight change has been controlled by CMOS-based neuron circuits in developments of neuromorphic systems, the self-organized synaptic operations demonstrated by the gap-type atomic switch showed the potential for developing new types of neuromorphic systems.

Recently we found that gapless-type atomic switch also shows the synaptic functions [3]. In the symposium, the synaptic functions achieved by gap-type and gapless-type atomic switches, and other novel functions those can be used in developing neuromorphic systems [4] are introduced.

References

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