ABSTRACT

Enhanced ion Diffusion in Dion–Jacobson Phase Two-Dimensional Halide Perovskite Thin Films for Neuromorphic Computing

Ho Won Jang[1,*], Soo Young Kim[2]

[1]Seoul National University, Seoul 08826, Republic of Korea.
[2]Korea University, Seoul 0284, Republic of Korea.

The exotic properties of three-dimensional halide perovskites, such as mixed ionic–electronic conductivity and feasible ion migration, have enabled them to challenge traditional memristive materials. However, the poor moisture stability and difficulty in controlling ion transport due to their polycrystalline nature have hindered their use as a neuromorphic hardware. Recently, two-dimensional (2D) halide perovskites have emerged as promising artificial synapses owing to their phase versatility, microstructural anisotropy in electrical and optoelectronic properties, and excellent moisture resistance [1]. However, their asymmetrical and nonlinear conductance changes still limit the efficiency of training and accuracy of inference. Here we achieve highly linear and symmetrical conductance changes in Dion–Jacobson 2D perovskites [2]. We further build a 7 × 7 crossbar array based on analogue perovskite synapses, achieving a high device yield, low variation with synaptic weight storing capability, multi-level analogue states with long retention, and moisture stability over 7 months. We explore the potential of such devices in large-scale image inference via simulations and show an accuracy within 0.08% of the theoretical limit. The excellent device performance is attributed to the elimination of gaps between inorganic layers, allowing the halide vacancies to migrate homogeneously regardless of grain boundaries. This was confirmed by first-principles calculations and experimental analysis.

[1] Kim, S.J. et al. Vertically aligned two-dimensional halide perovskites for reliably operable artificial synapses. Mater. Today 52, 19–30 (2022).
[2] Kim, S.J., Im, I.H., Baek, J.H. et al. Linearly programmable two-dimensional halide perovskite memristor arrays for neuromorphic computing. Nat. Nanotechnol. 20, 83–92 (2025).