



ReRAM-based Analog Synapse Devices for Neuromorphic System **Hyunsang Hwang, POSTECH**

To overcome the intrinsic limitations of von Neumann computing system with information bottleneck between memory and CPU, we need to develop neuromorphic computing system based on hardware artificial neural network (ANN). Hardware ANN system with high density synapse and neuron can perform massive parallel computing which is effective for pattern recognition and clustering of unstructured data. To implement neuromorphic system, we need to develop ideal synapse device with various requirements such as scalability, MLC characteristics, low power operation, data retention, and symmetric potentiation/depression characteristics. Although various devices such as filamentary ReRAM, PRAM, and MRAM were proposed for synapse applications, these devices cannot meet the requirements of synapse device.

Using redox reaction at metal/ $\text{Pr}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$ interface, we developed analog synapse device. Compared with filament switching device which has intrinsic variability of switching parameters, interface switching device exhibits excellent switching uniformity and area scalability. By controlling the reactivity of metal electrode and oxygen concentration in $\text{Pr}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$, we can modulate the resistance change characteristics under potentiation and depression conditions. We have fabricated wafer-scale high density synapse array device with excellent switching uniformity.

By modulating the linearity and symmetry of conductance change, we have estimated the accuracy of pattern recognition of handwritten digits. We found that synapse device with linear and symmetric conductance change exhibits the best accuracy of pattern recognition.