Efficient Neural Computing Enabled by Magneto-Metallic Neurons and Synapses

Brain inspired computing models like Artificial Neural Networks (ANN) and Spiking Neural Networks (SNN) have emerged as one of the powerful tools for pattern recognition and classification problems. Nano devices emulating the functionality of neurons and synapses are a crucial requirement for such neuromorphic computing platforms. Recent experiments on lateral spin valves (LSV) have demonstrated the switching of nano-magnets when the net spin potential in the non-magnetic channel due to injected spin-polarized current exceeds a certain threshold, thereby emulating the biological neuron. Programmable domain wall strips can be interfaced with such "spin-neurons" to inject weighted spin-polarized current in the channel to mimic the synaptic functionality. The low resistance, magneto-metallic neurons operate at a small terminal of ~50mV, while performing analog computation upon inputs leading to the possibility of ultra low power, low-voltage ANN based neuromorphic computing. On the other hand, a more biologically realistic computing model in comparison to ANNs, SNNs perform unsupervised learning by spike transmission and require the online programming of synapses based on the temporal information of spikes. Programmable resistive synapses based on ferromagnet-heavy metal hetero-structure offers the possibility of implementing Spike Timing Dependent Plasticity mechanisms by utilizing the highly energy-efficient spin-orbit torque. Results indicate that the proposed design schemes can achieve ~100X reduction in computation energy compared to the state of art CMOS designs.