Scalable Artificial Synapses with Tunable Temporal Dynamics

Feng Xiong, Electrical and Computer Department, Swanson School of Engineering, University of Pittsburgh

Motivation

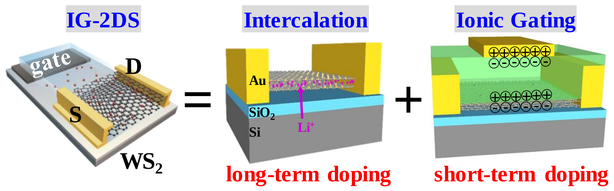
- Improve energy efficiency and computing performance by mimicking the human brain
- Spiking neural network (SNN) mimics the biological neural network more closely by incorporating the temporal dynamics
- Need a dynamic synapse with a tunable temporal dynamics, high-precision, and low power

Project Description

- Task 1: elucidate short- and long-term doping mechanisms
- Task 2: demonstrate tunable spatio-temporal dynamics for SNNs

Context

- Existing approaches: digital CMOS devices or non-volatile memory devices
- Limitations: energy intensive, no temporal dynamics, digital (not analog)
- Proposed approach: electrochemical 2D devices where the channel conductance can be tuned reversibly to achieve temporal dynamics and high precision
- Uniqueness: short- and long-term temporal dynamics due to intercalation and ionic gating



University of Pittsburgh

Build scalable synaptic arrays with programmable temporal dynamics, high-precision, and low power for the hardware implementation of spiking neural network.

Project Deliverables

- an in-depth understanding of the short- and long-term doping mechanisms in 2D synapses
- Control over both the amplitude and timing constants of the synaptic weight of 2D synapses
- Follow-up external funding strategy
  - Electronics, Photonics and Magnetic Devices program at NSF
  - Electronic Photonic Materials program at NSF
  - Quantum Electronics Solids program at Air Force Office of Scientific Research (AFOSR)
  - Semiconductor Research Corporations

Potential Impact

- Cognitive Computing
  - explainable AI models for logic inference
- Neuromorphic Vision System
  - event-based camera with high throughput and low power
  - For self-driving vehicle, robotics etc.
- Edge Computing
  - flexible and wearable electronics with low-power AI
- 2D Nanoelectronics
  - effective doping platform for 2D devices

References and/or Acknowledgements

- Sharbati, M. T.; Du, Y.; Torres, J.; Ardolino, N. D.; Yun, M.; Xiong, F., Low-power, electrochemically tunable graphene synapses for neuromorphic computing, Adv Mater 2018, 0, (0), 1802353
- Wan, Q.; Sharbati, M.; Erickson, J.; Du, Y.; Xiong, F., Emerging artificial synaptic devices for neuromorphic computing, Advanced Materials Technologies 2019

- Pitt Momentum Funds, University of Pittsburgh