2D Neuromorphic Computing Materials and Devices

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Abstract

The exponentially improving performance of digital computers has recently slowed due to the speed and power consumption issues resulting from the von Neumann bottleneck. In contrast, neuromorphic computing aims to circumvent these limitations by spatially co-locating logic and memory in a manner analogous to biological neuronal networks. Beyond reducing power consumption, neuromorphic devices provide efficient architectures for image recognition, machine learning, and artificial intelligence. This talk will explore how two-dimensional (2D) nanoelectronic materials enable gate-tunable neuromorphic devices. For example, by utilizing self-aligned, atomically thin heterojunctions, dual-gated Gaussian transistors have been realized, which show tunable anti-ambipolarity for artificial neurons, competitive learning, spiking circuits, and mixed-kernel support vector machines. In addition, field-driven defect motion in polycrystalline monolayer MoS_2 enables gate-tunable memristive phenomena that serve as the basis of hybrid memristor/transistor devices (i.e., 'memtransistors') that concurrently provide logic and data storage functions. The planar geometry of memtransistors further allows multiple contacts and dual gating that mimic the behavior of biological systems such as heterosynaptic responses. Moreover, control over polycrystalline grain structure enhances the tunability of potentiation and depression, which enables unsupervised continuous learning in spiking neural networks. Overall, this work introduces foundational circuit elements for neuromorphic computing by utilizing the unique quantum characteristics of 2D nanoelectronic materials.

Short Biography

Mark C. Hersam is the Walter P. Murphy Professor of Materials Science and Engineering, Director of the Materials Research Center, and Chair of the Materials Science and Engineering Department at Northwestern University. He also holds faculty appointments in the Departments of Chemistry, Applied Physics, Medicine, and Electrical Engineering. He earned a B.S. in Electrical Engineering from the University of Illinois at Urbana-Champaign (UIUC) in 1996, M.Phil. in Physics from the University of Cambridge (UK) in 1997, and Ph.D. in Electrical Engineering from UIUC in 2000. His research interests include nanomaterials, additive manufacturing, nanoelectronics, scanning probe microscopy, renewable energy, and quantum information science. Dr. Hersam has received several honors including the TMS Robert Lansing Hardy Award, MRS Outstanding Young Investigator, U.S. Science Envoy, MacArthur Fellowship, AVS Medard Welch Award, and eight Teacher of the Year Awards. Dr. Hersam has been repeatedly named a Clarivate Analytics Highly Cited Researcher with over 650 peer-reviewed publications that have been cited more than 70,000 times. An elected member of the National Academy of Engineering and National Academy of Inventors, Dr. Hersam has founded two companies, NanoIntegris and Volexion, which are commercial suppliers of nanoelectronic and battery materials, respectively. Dr. Hersam is a Fellow of MRS, ACS, AVS, APS, AAAS, SPIE, and IEEE, and also serves as an Executive Editor of *ACS Nano*.