NCMN EQUATE
Emergent Quantum Materials and Technologies

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Mixed-Dimensional Heterostructures for Electronic and Energy Technologies

ABSTRACT

Layered two-dimensional (2D) materials interact primarily via van der Waals bonding, which has created opportunities for heterostructures that are not constrained by epitaxial lattice matching requirements [1]. However, since any passivated, dangling bond-free surface interacts with another via non-covalent forces, van der Waals heterostructures are not limited to 2D materials alone. In particular, 2D materials can be integrated with a diverse range of other materials, including those of different dimensionality, to form mixed-dimensional van der Waals heterostructures.

Furthermore, chemical functionalization provides additional opportunities for tailoring the properties of 2D materials and the degree of coupling across heterointerfaces. In this manner, a variety of optoelectronic and energy applications can be enhanced, including photodetectors, optical emitters, supercapacitors, and batteries [2-4]. Furthermore, mixed-dimensional heterostructures enable unprecedented electronic device function to be realized that exploit neuromorphic, opto-spintronic, and quantum phenomena [5-8].

In addition to technological implications for electronic and energy technologies, this talk will explore several fundamental issues, including band alignment, doping, trap states, and charge/energy transfer across mixed-dimensional heterointerfaces.

References:
[1] S. Hadke, et al., Chemical Reviews, 125, 835 (2025).
[2] M. I. B. Utama, et al., Nature Communications, 14, 2193 (2023).
[3] S. V. Rangnekar, et al., ACS Nano, 17, 17516 (2023).
[4] L. E. Chaney, et al., Advanced Materials, 37, 2305161 (2024).
[5] X. Yan, et al., Nature Electronics, 6, 862 (2023).
[6] H. Liu, et al., Nature Electronics, 7, 876 (2024).
[7] J. T. Gish, et al., Nature Electronics, 7, 336 (2024).
[8] X. Yan, et al., Nature, 624, 551 (2023).

BIO

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 nanoelectronic materials, additive manufacturing, scanning probe microscopy, renewable energy, sensors, neuromorphic computing, and quantum information science. Dr. Hersam has received several honors, including the Presidential Early Career Award for Scientists and Engineers, TMS Robert Lansing Hardy Award, MRS Mid-Career Researcher Award, AVS Medard Welch Award, U.S. Science Envoy, MacArthur Fellowship, and eight Teacher of the Year Awards.

Dr. Hersam has been repeatedly named a Clarivate Analytics Highly Cited Researcher with over 750 peer-reviewed publications that have been cited ~85,000 times. An elected member of the American Academy of Arts and Sciences, National Academy of Engineering, and National Academy of Inventors with over 170 issued and pending patents, Dr. Hersam has founded two companies, NanoIntegris and Volexion, which are suppliers of nanoelectronic and battery materials, respectively. Dr. Hersam is a Fellow of MRS, ACS, ECS, AVS, APS, AAAS, SPIE, and IEEE, and also serves as an Executive Editor of ACS Nano.

February 4 | 4 PM | 110 Jorgensen Hall