

# PURDUE MECHANICAL ENGINEERING

## Viskanta Tutorial



### What Are 2D Materials Good For?

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**Friday, September 1, 2023**

**11am – 1pm in Birck 1001**

**Lunch will be provided**

[Please RSVP here by 5pm on Wednesday, August 30](#)

This tutorial will present my (biased!) perspective of what two-dimensional (2D) materials could be good for. For example, they may be good for applications where their ultrathin nature and lack of dangling bonds give them distinct advantages, such as flexible electronics [1] or DNA-sorting nanopores [2]. They may not be good where conventional materials work sufficiently well, like transistors thicker than a few nanometers. I will focus on 2D materials for 3D heterogeneous integration of electronics, which presents significant advantages for energy-efficient computing [3]. In this context, 2D materials could be monolayer transistors with ultralow leakage [4] (thanks to larger band gaps than silicon), used as access devices for high-density memory [5]. Recent results from our group have shown monolayer transistors with record performance [6,7], which cannot be achieved with sub-nanometer thin conventional semiconductors, and the 2D performance could be further boosted by strain [8]. I will also describe some unconventional applications, using 2D materials as good thermal insulators [9] and as thermal transistors [10]. These could enable control of heat in “thermal circuits” analogous with electrical circuits. Combined, these studies reveal fundamental limits and some unusual applications of 2D materials, which take advantage of their unique properties.

**Refs:** [1] A. Daus et al., *Nature Elec.* 4, 495 (2021). [2] J. Shim et al. *Nanoscale* 9, 14836 (2017). [3] M. Aly et al., *Computer* 48, 24 (2015). [4] C. Bailey et al., *EMC* (2019). [5] A. Khan et al. *Science* 373, 1243 (2021). [6] C. English et al., *IEDM*, Dec 2016. [7] C. McClellan et al. *ACS Nano* 15, 1587 (2021). [8] I Datye et al., *Nano Lett.* 22, 8052 (2022). [9] S. Vaziri et al., *Science Adv.* 5, eaax1325 (2019). [10] M. Chen et al., *2D Mater.* 8, 035055 (2021).

**Bio:** Eric Pop is the Pease-Ye Professor of Electrical Engineering (EE) and Materials Science & Engineering (by courtesy) at Stanford, where he leads the SystemX Heterogeneous Integration focus area. His research interests include nanoelectronics, data storage, and energy. Before Stanford, he spent several years on the faculty of UIUC, and in industry at Intel and IBM. He received his PhD in EE from Stanford (2005) and three degrees from MIT in EE and Physics. His honors include the Intel Outstanding Researcher Award, the PECASE from the White House, and Young Investigator Awards from the Navy, Air Force, DARPA, and NSF CAREER. He is an APS and IEEE Fellow, an Editor of *2D Materials*, and a Clarivate Highly Cited Researcher. In his spare time, he enjoys snowboarding and tennis, and in a past life he was a college radio DJ at KZSU 90.1. More information about the Pop Lab is available at <http://poplab.stanford.edu> and on Twitter [@profericpop](https://twitter.com/profericpop)