2D materials for a new generation of multi-functional devices

Steven J. Koester

Professor, Department of Electrical and Computer Engineering, University of Minnesota, MN 55455, USA

Two-dimensional (2D) materials are layered crystals, defined by strong intra-layer covalent bonds and weak inter-layer van der Waals coupling, that possess many unique and interesting properties. In this talk, I describe recent advancements on 2D materials, and discuss new device concepts in electronics, photonics, spintronics and sensing, with a focus on applications where these materials can provide improved performance or enable new functionality compared to conventional materials. Graphene is a 2D sheet of sp^2-bonded carbon atoms, and while it has limited usefulness for field-effect transistors, graphene has applications in a wide range of other fields. Graphene is an excellent sensor material due to its high surface sensitivity, and we have gone beyond conventional sensors and shown that this sensing capability can be transduced into the wireless domain by utilizing the quantum capacitance effect. More recently, we have shown that metal-oxide-graphene devices can be used to create atomically sharp “tweezers” for trapping biomolecules such as DNA at voltages as low as 700 mV, making them suitable for integration with CMOS readout circuits. We have also developed novel graphene-based spintronic devices, include devices for hard drive read heads and low-power spin-neuromorphic computing architectures. 2D semiconductors also have a multitude of uses as integrated electronic and photonic elements. In particular, we have shown that MoS_2, a transition metal dichalcogenide (TMD), is ideal for dynamic random access memories (DRAMs), where the wide band gap and heavy effective mass make it an ideal platform for ultra-low leakage access transistors. On the other hand, black phosphorus (BP), with its narrow band gap and low effective mass is ideal for use in high-speed photodetectors, high-performance MOSFETs and tunneling field-effect transistors.

Biography

Dr. Koester received his Ph.D. in 1995 from the University of California, Santa Barbara. From 1997 to 2010 he was a research staff member at the IBM T. J. Watson Research Center and performed research on a wide variety of electronic and optoelectronic devices, with an emphasis on those utilizing the Si/SiGe material system. Since 2010, he has been a Professor of Electrical & Computer Engineering at the University of Minnesota where his research focuses on novel electronic, photonic and sensing device concepts with an emphasis on 2D materials. Dr. Koester has authored or co-authored over 250 technical publications, conference presentations, and book chapters, and holds 68 United States patents. He is a Fellow of the IEEE.