Materials Science and Engineering Department

Spring Seminar Series

Heterostructures for Logic, Memory and Photonics

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The isolation of a growing number of two-dimensional (2D) materials has inspired worldwide efforts to integrate distinct 2D materials into van der Waals (vdW) heterostructures. While a tremendous amount of research activity has occurred in assembling disparate 2D materials into "all-2D" van der Waals heterostructures and making outstanding progress on fundamental studies, practical applications of 2D materials will require a broader integration strategy. I will present our ongoing and recent work on integration of 2D materials with 3D electronic materials to realize logic switches and memory devices with novel functionality that can potentially augment the performance and functionality of Silicon technology. First, I will present our recent work on gate-tunable diode and tunnel junction devices based on integration of 2D chalcogenides with Si and GaN. Following this I will present our recent work on non-volatile memories based on Ferroelectric Field Effect Transistors (FE-FETs) made using a heterostructure of MoS_2/AlScN and I also will present our work on Ferroelectric Diode devices also based on thin AlScN.

Next, I will present our work on light-trapping in excitonic systems namely, 2D chalcogenides and halide perovskites. I will present the effect of nano-structuring on hybridization between excitons, plasmons and cavity photons. I will extend this concept to artificial superlattice of 2D excitonic materials as well as natural superlattices in the form of 2D halide perovskites[8] and demonstration of hybrid exciton-polariton emission at room temperatures. If time permits, I will also discuss our recent work where we demonstrate coupling between spin-order and optical response in van der Waals antiferromagnetic semiconductors. I will end by giving a broad perspective on future opportunities of 2D and other low-dimensional materials in basic science and applied microelectronics technology.

Deep Jariwala is an Assistant Professor in Department of Electrical and Systems Engineering at the University of Pennsylvania (Penn). His research interests broadly lie at the intersection of new materials, surface science and solid-state devices for computing, sensing, opto-electronics and energy harvesting applications. Deep completed his undergraduate degree in Metallurgical Engineering from the Indian Institute of Technology, Banaras Hindu University in 2010. Deep went on to pursue his Ph.D. in Materials Science and Engineering at Northwestern University graduating in 2015. At Northwestern, Deep made contributions to the study of charge transport and electronic applications of two-dimensional (2D) semiconductors and pioneering the study of gate-tunable, mixed-dimensional, van der Waals heterostructures. Deep then moved to Caltech as a Resnick Prize Postdoctoral Fellow from 2015-2017 working on nanophotonic devices and ultrathin solar cells before joining Penn in 2018 and starting his own group. Deep's research has earned him awards of multiple professional societies including the Russell and Sigurd Varian Award and Paul H. Holloway Award of the American Vacuum Society, The Richard L. Greene Dissertation Award of the American Physical Society, Johannes and Julia Weertman Doctoral Fellowship, the Hilliard Award, the Army Research Office Young Investigator Award, Nanomaterials Young Investigator Award, TMS Frontiers in Materials Award, Intel Rising Star Award, IEEE Young Electrical Engineer of the Year Award, IEEE Photonics Society Young Investigator Award, IUPAP Early Career Scientist Prize in Semiconductors in addition to being named in Forbes Magazine list of 30 scientists under 30 and is an invitee to Frontiers of Engineering conference of the National Academy of Engineering and a recipient of the Sloan Fellowship. He serves on the Editorial board of the journals *Electronics* and *Micromachines*. He has published over 95 journal papers with more than 14000 citations and 7 patents. At Penn he leads a research group comprising more than ten graduate and postdoctoral researchers supported by a variety of government agencies (NSF, DARPA, ARO, AFOSR), industries and private foundations.

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