2D Semiconductors: Materials, Interfaces, and Devices

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Two-dimensional (2-D) semiconductors exhibit excellent device characteristics, as well as novel optical, electrical, and optoelectronic characteristics due to quantum size-effects. In this talk, I will discuss our recent advancement in exploring 2D materials based on free-standing transition metal chalcogenides (MoS_2 and WSe_2) and III-V semiconductors on Si/SiO2 substrates. The resulting X-on-insulator (XOI) substrates enable the exploration of a wide-range of device applications, while allowing for fundamental science exploration of the carrier properties as a function of thickness, without the constraints of the original growth substrates. Specifically, the quantized sub-bands of ultrathin semiconductor membranes (3-20 nm in thickness) are directly visualized by optical absorption studies. Through experiments and modeling, the drastic role of carrier quantum confinement on contact resistance and transport properties is discussed. Finally, surface charge transfer doping of 2D semiconductors is presented as a promising route for controlling the carrier concentration while lowering the contact resistance. Overall, the results shed light on the performance limits of 2D transistors.