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2D MATERIALS, FLEXIBLE ELECTRODES AND SURFACES

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I will present three of our primary research topics, as each relates to 1D/2D materials, substrates and surfaces. Firstly, I will focus on our investigation of chemical vapor deposition (CVD)-growth, achieving localized, patterned, single crystalline or polycrystalline monolayers of TMDs, including MoS_2, WS_2, WSe_2 and $MoSe_2$, as well as their heterostructures. We study CVD-growth and perform extensive material characterization to illuminate the role of dissimilar 2D substrates in the prevention of interior defects in TMDs, thus uncovering the conditions for anti-oxidation. We further demonstrate the epitaxial growth of TMDs on hBN and graphene, as well as vertical/lateral heterostructures of TMDs, uniquely forming in-phase 2D heterostructures. This research provides a detailed observation of the oxidation and anti-oxidation behaviors of TMDs, which corroborate the role of underlying 2D layers in the prevention of interior defects in TMDs. If the technique could be developed to be highly reliable and high fidelity, it could have a large impact on the future research and commercialization of TMD-based devices. The second research area concerns our development and application of flexible electrodes and energy storage toward wearable and multifunctional electronics. Here, we develop a facile fabrication technique utilizing vertically aligned carbon nanotubes (VACNTs), which enables high-throughput fabrication of flexible supercapacitors. We develop an innovative technique, which facilitates a stable charge/discharge under varied strains. Our structure shows a high flexibility and stability during stretching up to 20% and bending up to 180°. These flexible supercapacitors are promising for various flexible electronics applications. Lastly, we investigate and utilize smart polymer functional surfaces using dodecylbenzenesulfonate-doped polypyrrole (PPy(DBS)); we demonstrate a novel *in situ* control of droplet pinning on the polymer surface, enabling the control of droplet adhesion from strongly pinned to extremely slippery (and vice versa). The pinning of organic droplets on the surfaces is dramatically controlled *in situ*, presenting great potential for manipulation and control of liquid droplets for various applications including oil separation, water treatment and anti-bacterial surfaces. In addition, we demonstrate controlled lateral actuation of organic droplets on PPy (DBS) electrodes in an aqueous environment. We believe that our work represents a major advance in materials science and engineering, especially pertaining to those topics that involve functional and tunable surfaces.