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1D and 2D materials, flexible electrodes and tunable surfaces

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I will present three of our primary research topics, as each relates to 1D/2D materials, substrates and surfaces. First, I will focus on our investigation of chemical vapor deposition (CVD)-growth of transition metal dichalcogenides (TMDs) as well as their heterostructures, and characterization to illuminate the role of dissimilar 2D substrates in the prevention of interior defects in TMDs. 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 electrodes. For example, our structure shows a high flexibility and stability during stretching up to 20% and bending up to 180 degrees, 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. 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.

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