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Printable Two-Dimensional Nanomaterial Inks for Electronic and Energy Applications

Layered two-dimensional nanomaterials interact primarily via van der Waals bonding, which has created new opportunities for heterostructures that are not constrained by epitaxial growth [1]. In order to efficiently explore the vast phase space for van der Waals heterostructures, our laboratory employs solution-based additive assembly [2]. In particular, constituent two-dimensional nanomaterials (e.g., graphene, boron nitride, transition metal dichalcogenides, and black phosphorus) are isolated in solution, and then deposited into thin films with scalable additive manufacturing methods (e.g., aerosol, inkjet, gravure, and screen printing) [3]. By achieving high levels of nanomaterial monodispersity and printing fidelity, a variety of electronic, electrochemical, and photonic applications can be enhanced including digital logic circuits [4], lithium-ion batteries [5], and photodetectors [6]. Furthermore, by integrating multiple nanomaterial inks into heterostructures, unprecedented device function is realized including anti-ambipolar transistors [7], gate-tunable photovoltaics [8], and neuromorphic memristors [9]. In addition to technological implications for electronic and photonic technologies, this talk will explore several fundamental issues including band alignment, doping, trap states, and charge/energy transfer across two-dimensional van der Waals heterointerfaces [10].

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