Solution-Processed Graphene and Related 2D Nanomaterial Inks

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Two-dimensional nanomaterials have emerged as promising candidates for next-generation electronics and optoelectronics [1], but advances in scalable nanomanufacturing are required to exploit this potential in real-world technology. This talk will explore methods for improving the uniformity of solution-processed graphene and related two-dimensional nanomaterials with an eye toward realizing dispersions and inks that can be deposited into large-area thin-films [2]. In particular, density gradient ultracentrifugation allows the solution-based isolation of graphene [3], boron nitride [4], montmorillonite [5], and transition metal dichalcogenides (e.g., MoS_2, WS_2, $MoSe_2$, and WSe_2) [6] with homogeneous thickness down to the atomically thin limit. Similarly, two-dimensional black phosphorus is isolated in organic solvents [7] or deoxygenated aqueous surfactant solutions [8] with the resulting phosphorene nanosheets showing field-effect transistor mobilities and on/off ratios that are comparable to micromechanically exfoliated flakes. By adding cellulosic polymer stabilizers to these dispersions, the rheological properties can be tuned by orders of magnitude, thereby enabling two-dimensional nanomaterial inks that are compatible with a range of additive manufacturing methods including inkjet [9], gravure [10], screen [11], and 3D printing [12]. The resulting printed two-dimensional nanomaterial structures show promise in several applications including photodiodes [13], anti-ambipolar transistors [14], gate-tunable memristors [15], and heterojunction photovoltaics [16].

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