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2D and Layered Materials for Additive Manufacturing of Energy Storage and Harvesting Devices

David Estrada, Ph.D.
Micron School of Materials Science and Engineering
Boise State University, Boise, ID USA
daveestrada@boisestate.edu

Abstract

The rapidly evolving field of two-dimensional (2D) materials continues to drive advances in electronics, energy, and sensing. Progress in synthesizing 2D and layered-material inks has expanded the design space for printed thin films, though achieving rheologically stable inks for materials-jetting platforms remains a core challenge requiring careful solvent engineering. This talk highlights our recent work in additive manufacturing of 2D and layered materials, including aerosol jet printing of MXenes, transition-metal dichalcogenide alloys, and Bi_2Te_3 thermoelectrics for energy storage and harvesting.[1-4] We introduce a long-term-stable, aerosol-jet-printable $Ti_3C_2T_x$ MXene ink that produces high-resolution features (~45 µm) with minimal overspray. Printed MXene supercapacitors reach 122 mF cm^{-2} areal and 611 F cm^{-3} volumetric capacitance, among the highest reported for printed devices.[1] For energy harvesting, triboelectric nanogenerators (TENGs) based on an eco-friendly PVBVA/MXene composite yield a power density of 760 mW m^{-2} and 129% and 250% increases in open-circuit voltage and short-circuit current.[2] We also demonstrate controlled solvothermal synthesis of Bi_2Te_3 nanoplates, where morphology and porosity tune systematically with temperature and reaction time.[3] These nanocrystals (35 ± 15 nm thick, 692 ± 186 nm lateral dimension) form flexible thin films on polyimide using scalable, low-cost methods, achieving a peak power factor of 0.35 mW m^{-1} K^{-2} at 433 K, among the highest for flexible thermoelectrics [4]. Collectively, these results underscore how 2D and layered-material inks are enabling scalable, cost-effective additive-manufacturing pathways for next-generation energy storage and harvesting technologies across wearable electronics, sensing, healthcare, and soft robotics.

References

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