**Aligned Micropatterning of Ti3C2Tx MXene on Polymer Pattern via Hybrid Additive Manufacturing**

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The MXene (Ti3C2Tx) nanoparticle bulk composite and free-standing thin films have been used for various applications due to their unique collective properties. Thus, achieving controlled alignment of stacked MXene with nano to microscale patterning on complex 3D architectures is essential for tuning the functional properties of the composite structures. In this work, the rapid and scalable method to fabricate well-aligned thin film of MXene by combining μCLIP 3D printing and capillary-driven self-assembly technique has been studied. This technique showed potential for rapid, scalable, and low-cost fabrication of printed electronics. For deposition, single/multi-layered MXene flakes solution was confined into microchannels via capillary action leading to the formation of highly ordered and aligned MXene film. During the evaporation-drying process, the solid-liquid-air contact line is molded by the shape of the gratings, and the nanoparticle experiences various long-range and short-range microfluidic forces which promote the layer-by-layer deposition of nanoparticles. The stacked film displayed strong plane to plane and out-of-plane adherence, with the film of ~5 μm thickness and anisotropic electronic properties. Moreover, the film has been produced from concentration-well-controlled solutions showing efficient use of materials. The 3D printed template enables a large area of thin film deposition of MXene on complex architecture while protecting film structure from mechanical deformations. The devived demonstrated high sensitivity, wide sensing range, and excellent durability, which makes it suitable for the piezoresistive sensor. In addition, this synergistic approach shows enormous potential for nanomaterial assembly and broad applications, such as structural composites, sensors, actuators, human−machine interfaces, cryptosecurity, and soft robotics.

**Keywords:** Self-assembly, Two-dimensional nanoparticles, Additive manufacturing, Polymer nanocomposite, Piezoresistive sensor.

Diagram

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