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Aligned Ti3C2Tx MXene for 3D Micropatterning via Additive Manufacturing

Background

Nanoparticles can be selectively deposited and aligned on complex and flexible substrates in order to tune material properties and enrich structural versatility for applications in microelectronics, optoelectronics, sensors, and human-machine interfaces. However, it is difficult for most current nanoprocessing methods to effectively manipulate nanoparticles to achieve manufacturing scalability and repeatability. Current methods include chemical vapor deposition (CVD), self-assembly, coating, ultraviolet (UV) lithography, and stamping.

3D printing technology using layer-by-layer additive manufacturing can provide certain advantages over current nanoprocessing methods including rapid prototyping, complex designing, wide range of material choices, and minimized waste. However, current 3D printing techniques including direct inkjet, screen printing, fused deposition modeling (FDM) and stereolithography (SLA) all suffer technical difficulties including slow manufacturing speed, low resolution, limited choice of printing materials, and lack of depositional selectivity. None of these current techniques can achieve nanoscale feature control and have acceptable scalability up to only micro- or macro-structures.

Most current 3D printing nanoprocessing methods use 1D or 0D nanospheres as nanomaterials, but there is a challenge with scalable manufacturing of 2D materials as they tend to form clusters composed of rippled sheets and are thermodynamically unstable. MXene possesses a unique set of properties as a 2D nanoparticle, including customizable dimensions, tunable surface charges, and excellent dispersity suitable for assembling hierarchical architectures.

Invention Description

Researchers at Arizona State University have developed a novel hybrid 3D printing method for orientational alignment and positional patterning of 2D MXene nanoparticles that is both scalable and straightforward. This process involves surface topology design through micro-continuous liquid interface production and directed assembly of MXene flakes through capillarity-driven direct ink writing. This method allows for preferential alignment of MXene sheets by layer-by-layer additive depositions through constraint of MXene suspensions and leveraging of the microforces.

Potential Applications

- Wearable health monitoring
- Soft robotics

- Human-machine interfaces

Benefits & Advantages

- Anisotropic conductivity and piezoresistive sensing with a wide sensing range
- High sensitivity
- Fast response time
- Mechanical durability
- Low-cost manufacturing

Related Publication: "Aligned $Ti_3C_2T_x$ MXene for 3D Micropatterning via Additive Manufacturing" | ACS Nano (2021).