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Multiphase Direct Ink Writing for 3D Printing

-Additive manufacturing, commonly known as 3D printing, is a manufacturing technique that builds layer-by-layer materials. 3D printing has advantages over traditional manufacturing with respect to rapid prototyping, complicated design, and material sustainability. Commonly used 3D printing mechanisms include vat-polymerization, material jetting, material extrusion, and powder-based-fusion. A bottleneck in 3D printing (e.g., in 3D printing polymer/nanoparticle composites) is the lack of high-precision control, especially without sacrificing manufacturing rates.

Direct ink writing (DIW) is an example of material extrusion 3D printing. A weakness of DIW is fragile and weak resultant structures, limiting its primary applications to materials that do not require high stiffness. A DIW 3D printing method is needed that considers manufacturing precision control, manufacturing rates, and mechanical properties of printed materials.

Researchers at Arizona State University have developed a 3D printing method, multiphase direct ink writing (MDIW), that is capable of printing multilayered and multiphased composite structures. The layered structures are achieved by two co-extruding immiscible feedstocks with similar viscosities through a printhead to form continuous ink deposited structures fabricated along a plane transverse to the flow direction of feedstock extrusion. This method showed one-step processing with a printing speed up to 1200 mm/min and a high precision control down to unit microns. The most refined printing features are two orders of magnitude higher than many ink- or gel-based 3D printing methods.

Related publication: Multiphase direct ink writing (MDIW) for multilayered polymer/nanoparticle composites

Potential Applications:

- 3D printing of layered structures, such as the following:
  - thin-ply laminates
  - thermally insulated or fire-retardant materials
  - microelectronics
  - solar arrays and antennas
  - optically reflective materials
  - biomedical scaffolds
  - packaging with gas barriers
  - stretchable packaging
  - smart and intelligent systems
  - untethered miniature soft robotics

Benefits and Advantages:

- Printing speeds of ~1200 mm/min
- Improved manufacturing precision of fine features with printing feature size as small as ~ 4 μm
- Production of 3D printed materials with versatile structures and better mechanics (e.g., modulus, strength, and energy absorption)
- Compatible with a broad range of inks in the form of natural and synthetic polymers and biopolymers
- High potential in surface patterning, layered laminates, circular scaffolds, and other functionally graded structures