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3D PRINTING OF ENCAPSULATED CONTINUOUS METAL WIRES

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ABSTRACT

The integration of smart materials into additive manufacturing (AM) processes has the potential to revolutionize the design and functionality of adaptive structures by enabling the creation of composites with specific properties and multifunctional capabilities. To integrate these smart materials inside a polymer matrix, this study presents a novel approach to embed a continuous metal wire using a custom-designed print head. By leveraging the Direct Ink Writing (DIW) process—i.e., the deposition of shear-thinning inks in layers on a moving stage, followed by their solidification—the print head enables simultaneous extrusion of a polymer ink and a continuous metal wire, e.g. copper wire.

In the first phase of experimentation, the print head was positioned at a fixed height above the print surface, allowing both materials to extrude freely under gravity. To demonstrate the ability of our custom-print-head, we use an off-the-shelf polymer—Gorilla Clear Grip, a highly viscous compound composed of toluene and naphtha (petroleum)— to encapsulate the metal wire up to a predetermined sample length. Then, the sample is cut and hung to dry for 24 hours. The composite was analyzed under a microscope, revealing continuous coating with only slight deformities, resulting in an effective encapsulation of the wire within the polymer matrix.

However, challenges arose when attempting to directly deposit the encapsulated wire onto the print bed. Despite the high viscosity of the polymer, maintaining the wire's central position within the coating proved difficult without any external shape retention mechanisms. Shape retention thus, required an additional force to restrain the metal wire and to conform it to a desired shape after printing. This was in addition to ensuring alignment and uniform encapsulation of the wire within the polymer during the printing process. These challenges highlight the intricate interplay between material flow dynamics, extrusion synchronization, and mechanical constraints.

The current printing status, demonstrates the feasibility of producing wire-reinforced composites through additive manufacturing but underscores the need for further optimization of process parameters to achieve precise control during deposition. With our efforts, we work towards overcoming these challenges and contribute to the advancement of additive manufacturing technologies for the fabrication of intelligent structures.