Research team unlocks new method to 3D-print complex, functional components for soft robotics

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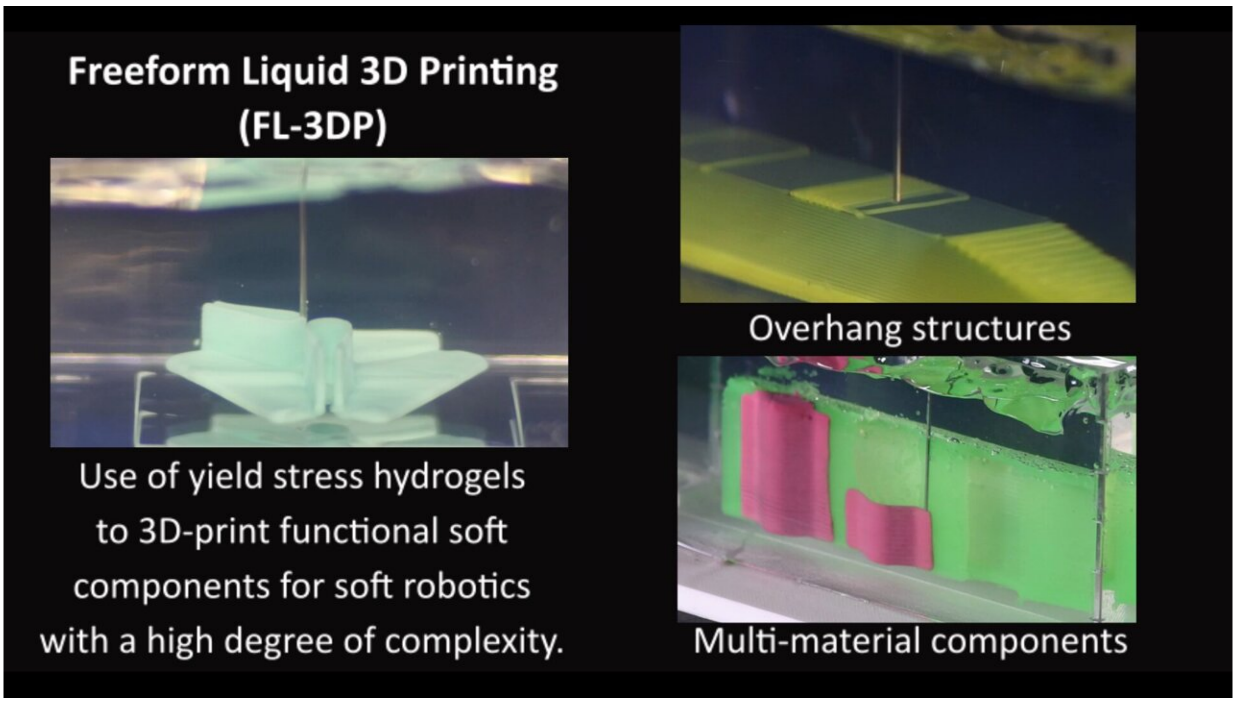

Use of yield stress hydrogels to 3D-print functional soft components for soft robotics with a high degree of complexity. Credit: SUTD

A team of researchers from the Singapore University of Technology and Design (SUTD) has developed a new approach for adopting the Freeform Liquid 3D Printing (FL-3DP) technology to 3D print more robust and geometrically complex components for soft robotics.

FL-3DP is an emerging technology with high potential that enables the 3D printing of multi-material functional components. It uses gel as a temporary suspension media in which inks are extruded and held in place. Once the inks are solidified, the gel can then be easily washed off.

This approach overcomes two major limitations faced in existing 3D printing technologies. Firstly, it enables the 3D-printing of materials that take a long time to solidify when extruded. Secondly, due to its ability to hold inks and maintain them in the liquid state, advanced geometries such as overhanging structures shapes with high-aspect ratios or fine combinations of multiple materials have now become a feasible option.

However, early FL-3DP was found to have limited features when fabricating advanced components, as only mono-material structures or simple shapes such as meshes and shells could be demonstrated. The absence of more complex demonstrators, despite the promises of this technology, could be partly explained by difficulties in controlling the interfaces between the inks and supports, thus challenging the printing resolution.

Through an in-depth study of the rheological properties and interfacial stabilities between inks and support gels, SUTD researchers managed to better predict the filament shape, which led to improved printing resolution and fidelity.

This outcome enabled the full exploitation of FL-3DP technology through the fabrication of complex elastomeric-based components combining multiple materials and the enhancement of the range in complex geometrical prints. Their paper "Freeform Liquid 3D Printing of Soft Functional Components for Soft Robotics," which summarizes these key findings, was published in *ACS Applied Materials & Interfaces*.

To demonstrate the advantages of FL-3DP over traditional manufacturing approaches including casting and molding, the researchers designed and fabricated advanced pneumatic components for soft robotics applications specifically used in soft grippers. By combining stiff, soft and functional elastomers, they were able to precisely control the shape deformation of the components, to tune their functionalities by adjusting the friction of soft gripper surfaces or by providing sensing capabilities, and enhance the lifespan of components by up to ten times compared to their traditional cast counterparts.

These results are part of a global effort to mark a new era for extrusion-based 3D printing by using suitable suspension media. This enhanced approach also offers a broader design space to designers and engineers, and could benefit many applications, such as soft robotics where complex and robust combinations of a wide range of materials and functionalities are required.

The team is now working on widening the range of processable materials by developing new suspension media that are chemically compatible with more inks.

"FL-3DP and other new extrusion-based additive manufacturing processes are getting us closer and closer to the ultimate target goal of full direct co-fabrication of complex functional systems such as robots and other complex functional products and devices," said principal investigator Assistant Professor Pablo Valdivia y Alvarado from SUTD.

More information: Théo Calais et al, Freeform Liquid 3D Printing of Soft Functional Components for Soft Robotics, *ACS Applied Materials & Interfaces* (2021). DOI: 10.1021/acsami.1c20209

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