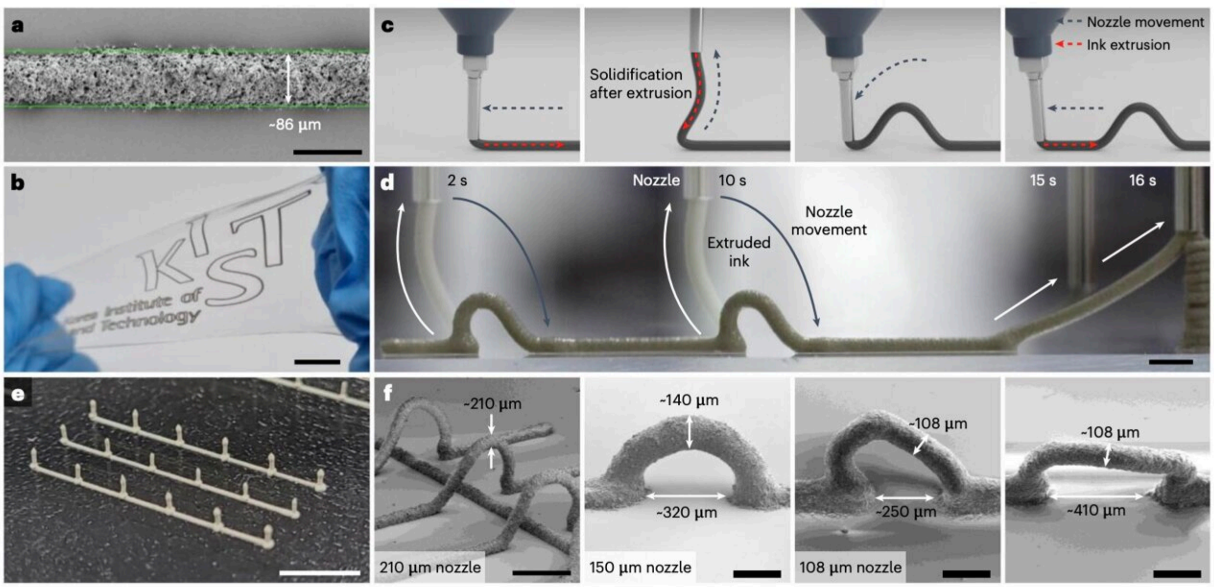
3D printed elastic conductors for stretchable electronics

May 11 2023, by Ingrid Fadelli



Omnidirectional printing of elastic conductors. a. SEM images showing the minimum width of our printing method with emulsion-based inks. Scale bar, 100 µm. b, Photograph of complex patterns of the printed elastic conductor being stretched. Scale bar, 1 cm. c, Schematic of the direct writing process for unsupported spanning geometries that enable soft conductors to directly cross the other electrodes, preventing undesired electrical interferences. d, Composite image of an elastic wiring with a series of self-supporting 3D geometries. The optical images of the nozzle head for each printing step were layered to illustrate the omnidirectional printing process. Scale bar, 1 mm. e, Photograph of a directly written elastic conducting pillar array. Scale bar, 5 mm. f, SEM images of omnidirectionally printed arch-shaped soft interconnects with different filament diameters and printing parameters. Scale bars, 1 mm and 200 µm. Credit: Lee et al, *Nature Electronics* (2023). DOI: 10.1038/s41928-023-00949-5

Three-dimensional (3D) printing has become increasingly advanced over the past few years and has been successfully used to create countless items, including toys, furniture and electronic components. As 3D printing equipment becomes more affordable, it could potentially also be used to fabricate soft electronic components for wearable devices.

Despite its promise in this area, so far 3D printing has rarely been successfully used to produce complex and flexible electronics. One reason for this is that solid-state elastic materials that can conduct electricity are difficult to print using existing inks.

Researchers at Korea Institute of Science and Technology recently demonstrated the successful use of 3D printing to create elastic components that can conduct electricity. Their proposed printing strategy, outlined in a paper in *Nature Electronics*, could potentially pave the way toward the large-scale printing of multi-functional and stretchable components for wearable devices.

The team's realization of elastic conductors using 3D printing was in great part enabled by a new emulsion-based composite ink they devised. This special ink consists of liquid components dispersed within a conductive elastomer, a rubbery material that conducts electricity.

"Printing solid-state elastic conductors with three-dimensional geometries is challenging because the rheological properties of existing inks typically only allow for layer-wise deposition," Byeongmoon Lee, Hyunjoo Cho and their colleagues wrote in their paper.

"We show that an emulsion system—consisting of a conductive elastomer composite, immiscible solvent and emulsifying solvent—can be used for the omnidirectional printing of elastic conductors. The viscoelastic properties of the composite provide structural integrity to the printed features—allowing freestanding, filamentary and out-of-plane three-dimensional geometries to be directly written—and pseudo-plastic and lubrication behaviors that provide printing stability and prevent nozzle clogging."

The composite ink used by the researchers has numerous advantageous properties compared to other inks commonly used in 3D printing. Specifically, it exhibits viscoelasticity, shear-thinning and lubricating properties, which better support the printing of complex 3D structures.

"Printed structures of the intrinsically stretchable conductor exhibit a minimum feature size less than 100 μm and stretchability of more than 150%," Lee, Cho and their colleagues wrote in their paper. "The vaporization of the dispersed solvent phase in the emulsion results in the formation of microstructured, surface-localized conductive networks, which improve the electrical conductivity."

To demonstrate the potential of their 3D printing approach and the emulsion-based ink they designed, the researchers printed elastic interconnects that they then used to create a wearable temperature sensor with a stretchable display. This device was found to perform well and the same method could soon also be used to create various other stretchable and conducting components.

In their paper, Lee, Cho and their colleagues highlight the possibility of combining their approach with 3D scanning technologies to create soft electronics that are perfectly aligned with the shape of the human body and thus more comfortable for users to wear. In addition, the ink they created could inspire the creation of other emulsion-based inks that operate similarly but are based on different compositions and elastomers.

More information: Byeongmoon Lee et al, Omnidirectional printing of elastic conductors for three-dimensional stretchable electronics, *Nature Electronics* (2023). DOI: 10.1038/s41928-023-00949-5