![Tech Xplore]

3-D printed 'invisible' fibers can sense breath, sound, and biological cells

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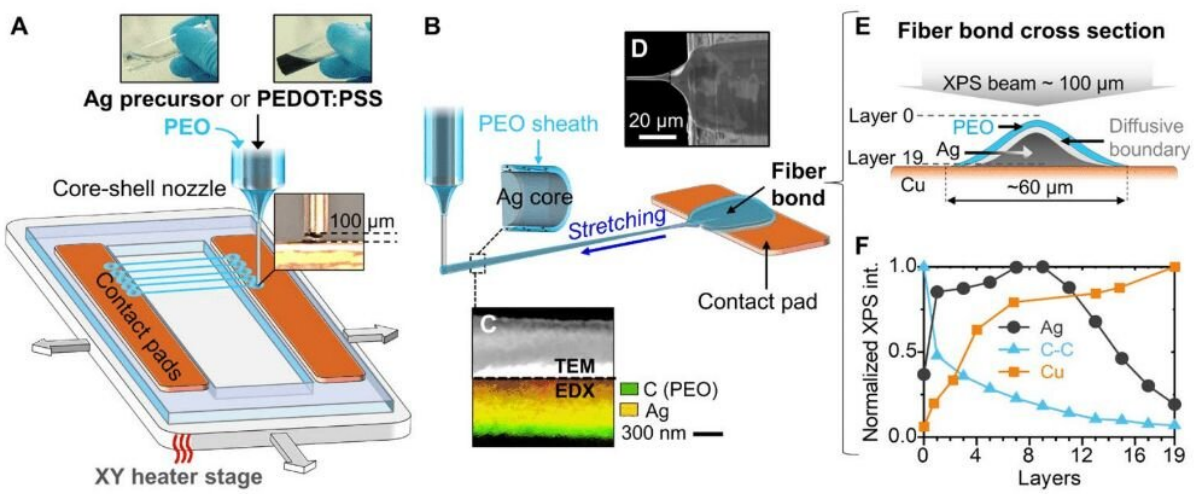

Credit: *Science Advances* (2020). DOI: 10.1126/sciadv.abd1882

From capturing your breath to guiding biological cell movements, 3-D printing of tiny, transparent conducting fibers could be used to make devices which can 'smell, hear and touch'—making it particularly useful for health monitoring, Internet of Things and biosensing applications.

Researchers from the University of Cambridge used 3-D printing, also known as additive manufacturing, techniques to make electronic fibers, each 100 times thinner than a human hair, creating sensors beyond the capabilities of conventional film-based devices.

The fiber printing technique, reported in the journal *Science Advances,* can be used to make non-contact, wearable, portable respiratory sensors. These printed sensors are high-sensitivity, low-cost and can be attached to a mobile phone to collect breath pattern information, sound and images at the same time.

First author Andy Wang, a Ph.D. student from Cambridge's Department of Engineering, used the fiber sensor to test the amount of breath moisture leaked through his face covering, for respiratory conditions such as normal breathing, rapid breathing, and simulated coughing. The fiber sensors significantly outperformed comparable commercial sensors, especially in monitoring rapid breathing, which replicates shortness of breath.

While the fiber sensor has not been designed to detect viral particles, since scientific evidence increasingly points to the fact that viral particles such as coronavirus can be transmitted through respiratory droplets and aerosols, measuring the amount and direction of breath moisture that leaks through different types of face coverings could act an indicator in the protection 'weak' points.

The team found that most leakage from fabric or surgical masks comes from the front, especially during coughing, while most leakage from N95 masks comes from the top and sides with tight fittings. Nonetheless, both types of face masks, when worn properly, help to weaken the flow of exhaled breath.

"Sensors made from small conducting fibers are especially useful for volumetric sensing of fluid and gas in 3-D, compared to conventional thin film techniques, but so far, it has been challenging to print and incorporate them into devices, and to manufacture them at scale," said Dr. Yan Yan Shery Huang from Cambridge's Department of Engineering, who led the research.

Huang and her colleagues 3-D printed the composite fibers, which are made from silver and/or semiconducting polymers. This fiber printing technique creates a core-shell fiber structure, with a high-purity conducting fiber core wrapped by a thin protective polymer sheath, similar to the structure of common electrical wires, but at a scale of a few micrometers in diameter.

In addition to the respiratory sensors, the printing technique can also be used to make biocompatible fibers of a similar dimension to biological cells, which enables them to guide cell movements and 'feel' this dynamic process as electrical signals. Also, the fibers are so tiny that they are invisible to the naked eye, so when they are used to connect small electronic elements in 3-D, it would seem that the electronics are 'floating' in mid-air.

"Our fiber sensors are lightweight, cheap, small and easy to use, so they could potentially be turned into home-test devices to allow the general public to perform self-administered tests to get information about their environments," said Huang.

The team looks to develop this fiber printing technique for a number of multi-functional sensors, which could potentially detect more breath species for mobile health monitoring, or for bio-machine interface applications.

More information: "Inflight fiber printing toward array and 3D optoelectronic and sensing architectures" *Science Advances* (2020). DOI: 10.1126/sciadv.aba0931 , advances.sciencemag.org/lookup … .1126/sciadv.aba0931

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