Gold-coated pantyhose inspire a technique for comfortable light-emitting clothing

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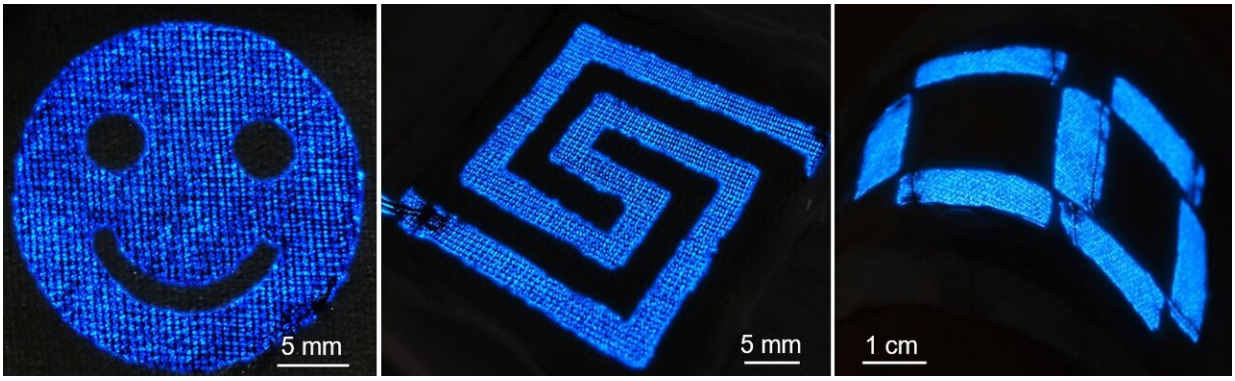

These photographs show light-emitting textiles displaying the 'smiling face' emoji, a rectangular spiral, and the number 8. Credit: The Carmichael Lab

An approach for developing light-emitting fabric based on typical ultrasheer pantyhose coated in a thin gold film may enable the development of softer, more wearable luminous clothing, researchers in Canada report March 4 in the journal *Matter*. The work addresses some of the limitations of existing light-emitting fabrics and, with effective power sources, could be developed into more functional designs for safety gear worn by first responders and nighttime construction workers, light-emitting athletic apparel, avante garde and everyday fashion, or wearable advertisements and logos.

"Users want light-emitting displays that are integrated into fabrics so that

they are soft, lightweight, stretchable, washable, and wearable—just like ordinary clothing but with light-emitting panels that can illuminate the user or display graphics/information," says senior author Tricia Carmichael, a professor of surface and materials chemistry at the University of Windsor.

However, designing wearable fabrics with a high-tech twist has proven challenging. Existing fabrication methods work well for rigid surfaces such as glass, silicon wafers, or plastics, but with their interwoven yarns designed to move and stretch, the textiles in clothing are far from rigid. As a result, current approaches to producing light-emitting apparel that involve sewing stiff diodes, wires, and optical fibres into textiles result in garments that lack the stretchability and softness of their non-luminous counterparts. They are also difficult to wash. Realizing the importance of fitting light-emitting devices within these flexible and stretchable structures in order to develop luminous fabrics that feel like any other garment, Carmichael and colleagues took a different approach.

"The lead author on the present paper, Yunyun Wu, was out shopping for fabrics for her research and had a eureka moment: why not use sheer fabrics as a solution for forming the transparent conductor, a crucial element of all light-emitting devices?" says Carmichael. "A second lightbulb moment came when we thought of pantyhose as an ideal material to build the new electrodes."

The researchers used electroless nickel-immersion gold metallization, a solution-based metal-deposition technique often used to make printed circuit boards that only deposits metal on the nylon and spandex fiber surfaces, to coat pantyhose with a highly conductive gold film only about 100 nm in thickness. They found that the coating process allowed the pantyhose fabric to retain its semi-transparency and stretchiness. Using this new fabrication technique, the researchers next created patterned light-emitting textiles with the smiley-face emoji, as well as a dynamic

display comprised of seven rectangular segments that can rearrange to display numbers zero through nine.

Although gold can, of course, be pricey, Carmichael and colleagues believe its chemical stability and safety for skin make it an excellent choice for wearable materials. Since such a small quantity of gold (a coating 1,000 times thinner than a human hair) is needed to imbue textiles with the conductivity they need to light up, the researchers are not concerned about the metal's cost or other costs associated with scaling up production.

"We are optimistic about the ability to scale up the technology," says Carmichael. "The process we use to deposit the ultrathin gold coating on fabric fibers can be scaled up by increasing the volume of the plating solution, enabling processing of entire articles of clothing. We also use existing ultrasheer fabrics and thus do not require new textile manufacturing."

However, one major hurdle remains in the way of incorporating wearable light-emitting devices, in general, into everyday life: the ability to power them without bulky energy generators and storage systems.

"We are exploring the wide variety of textile architectures as an integral part of device electrode design to enable the seamless integration of brittle energy storage materials into textiles," says Carmichael.

More information: *Matter*, Wu et al.: "Stretchable Ultrasheer Fabrics as Semitransparent Electrodes for Wearable Light-Emitting e-Textiles with Changeable Display Patterns" www.cell.com/matter/fulltext/S2590-2385(20)30017-5 , DOI: 10.1016/j.matt.2020.01.017

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