Fabric displays in high resolution

Woven displays with a high number of light-emitting pixels can be created by interlacing two electrically conducting fibres and forming electroluminescent unites at the crossover points.

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Over the past 20 years, considerable research effort has been focused on the development of flexible displays, including light-emitting diode (LED) arranges integrated into flexible substrates, thin-film electroluminescent displays and textile fabric displays[1,2]. Textiles displays, in particular, have a number of intriguing properties such as being able to drape over complex three-dimensional objects. To be used in wearable applications, the devices must remain stable under repeated deformation and be able to withstand washing cycles. An idea fabric display should also allow unlimited image patterns with good pixel spatial resolution and full-colour production, Previous demonstrations include fabrics made from electroluminescent yearns or fibres[3-5], Lumalive fabrics integrated with LED arrays from Philips and fabrics that use side-emitting optical fibres as illuminating elements[6]. However, most demonstrations to date have been made with predetermined patterns or low pixel spatial resolution, Writing in Nature, Peining Chen, Huisheng Pengand colleagues now report a woven display with a high number of light-emitting pixels[7].

The researchers – who are based at institutes in China, Germany, the US and Australia – cerate their textile by interlacing two independent electrically conducting fibres in a weave structure that provides a suitable electric field to allow electroluminescent emission at the crossover points. The large number of pixels in the resulting fabrics leads to displays that have a high spatial resolution. A hierarchical architecture of fine fibres, and their crossover points, can then be used to design and manipulate the electric field and interfacial stress. This allows the stability of electroluminescent emission to be enhanced, interfacial fatigue to be reduced and device lifetime to be prolonged. With the help of established textile processes, large-area fabric displays can be produced. In particular, Chen and colleagues fabricate a 6-metre-long, 25-centimetre-wide display fabric that contains 500,000 electroluminescent unites that are spaced only around 800um apart. The variation of brightness among the units is less than 6.3%.

The electroluminescent units are created by intertwining two groups of threads that run perpendicular to each other in a woven fabric structure (Fig. 1). The first group is a transparent ionic-liquid-doped polyurethane gel fibre, and the second is a conductive silver-plated yarn that is coated with commercial zinc sulfide (ZnS) phosphor. The crossover points of the fibres form the illuminating element of the pixel, enabling true display functionality rather than predetermined patterns. For now at least, the display is single coloured as the colour selection of the phosphor coating is limited.

The electroluminescent materials used here, as well as their working principles and advantages for low power consumption and low heat generation, have been known for some time[3-5]. And by using similar phosphor materials sandwiched between a transparent electrode layer and a ground electrode layer, thin-film coated flexible display patches have previously been incorporated into garments such as jackets and t-shirts – crating commercial products that were available some 15 years ago. However, these suffered from a short service lifespan (use and washing), especially due to folding as the coating layer easily broke down.

The key difference offered in the work of Chen and colleagues is that the electroluminescent unit is at a fibre crossover point, rather than a sandwich structure of three flat layers. This fabric structure allows better manipulation of the mechanical properties of the constituent materials and the construction of the electroluminescent unit. The ionic-liquid-doped polyurethane gel ground fibre and phosphor-coated conductive yarns also play an important role here: the combination of soft and hard fibre contact points creates a stable and relatively uniform electric filed over the crossover points. The resulting densely packed fibre display can survive an impressive 100 cycles of acerated washing and drying, as well as bending, stretching and lateral compression tests.

The relatively large fabric created, which has small variation in electroluminescence brightness and high spatial resolution, suggests that manufacturing large pieces of fabric display using established fibre/textile processes should, in principle, be straightforward. However, whether display fabrics such as this can offer full-colour images remains to be seen. Without proper encapsulation, the exposed ZnS coating on the yarn may not last very long under abrasive conditions. There are also potential safety issues associated with ZnS if it directly contacts the skin or eyes, is inhaled into the lungs or enters the environment8. Furthermore, the rigid electronics control units are currently external to the fabrics, and the connections between the large number of fibres/yarns and untidy. The connections are the weakest points in the whole flexible-rigid hybrid system, and where failure occurs most often. The development of a single-line or a-few-line connection would be beneficial in terms of both system reliability and user convenience.

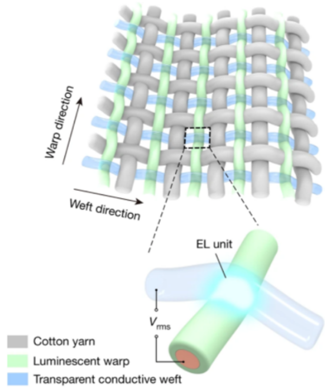

Fig 1. Fabric displays. Schematic showing the structure of the electroluminescent fabric display. Conductive ionic-gel-based fibres (the transparent conductive weft) and silver-plated nylon fibres that are coated with ZnS phosphor (the luminescent warp) are interwoven with cotton yarn. This creates a fabric in which electroluminescent (EL) light emission is possible at the points where the two electronic materials cross over. V_{rms} is the applied alternating voltage. Figure reproduced with permission from ref.[7] Springer nature Ltd.

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Competing interests
The author declares on competing interests.