and 4D (time-lapse 3D) images, and also extended to various platforms, ranging from smartphones, microscopes, automobiles and to medical imaging systems. "Also, AI will be utilized to design, manufacture, optimize, or even revolutionize various photonics devices. Many of the optical designs and processes for retrieving certain types of information, such as phase and spectroscopic, will be replaced by the software processing aided by AI. For example, it has been shown that fluorescence imaging of cells can be predicted by only measuring phase contrast images of the cells," said Park.

AI is surprisingly powerful and has taken the photonics community by storm. When asked about the future opportunities and challenges facing AI in photonics, Jalali said "the near-term opportunity is intelligent photonic sensors nodes and networks realized by combining electronic AI with photonic sensors. These nodes and networks will rely on not only inference but also on the use of AI to mitigate impairments in optical systems, such as improving the resolution, dynamic range and sensitivity, which is denoising. Another application is to use AI to come up with the optimum design for optical systems. A longer-term opportunity is the creation of analog optical computing primitives that function as photonic hardware accelerators to alleviate the burden on the electronic AI."

Nevertheless, Jalali says that it is just the beginning and the full potential of AI combined with photonics is still to be explored. He pointed out that a new area of research is optics-inspired digital algorithms. "These are computational algorithms that mimic optical physics. An example is the phase-stretch transform whose algorithm emulates near-field time stretch and coherent optical detection. It is emerging as the best edge and texture recognition algorithm in computational imaging."

From physics-inspired optical designs and devices, we are now heading towards data-driven designs that will change both optical hardware and software systems of the next generation. The amalgamation of AI with cutting-edge optics will have a transformative impact on communications, imaging and sensing systems, and perhaps many more applications. It would be interesting to see where AI drives the photonics community to in the next few years, and certainly, the next CLEO-PR that will be held in Sydney, Australia from 2–6 August 2020, is a good place to get an update. ❐

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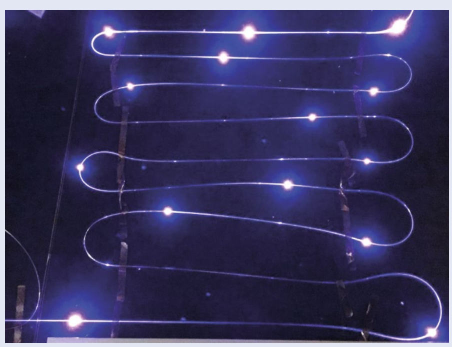
Published online: 27 September 2018
https://doi.org/10.1038/s41566-018-0265-6

OPTICAL FIBRES

Fabric optoelectronics

The idea of clothing that can communicate by light may sound like a fantasy but that's exactly what scientists from the US and Switzerland have now achieved. Writing in *Nature*, Michael Rein and co-workers report how they have successfully found a way to integrate discrete semiconductor p–n-diode-based light-emitting diodes (LEDs) and photodetectors and their metal wire connections into optical fibres that can then be woven into a separate textile fabric (*Nature* **560**, 214–218; 2018). In-fibre arrays of InGaN and AlGaAsP LEDs emitting blue, green and red light and GaAs p–i–n photodetectors have all been demonstrated (pictured), opening the door to fabrics that support visible-light fibre communications and sensing.



Credit: Springer Nature Ltd

The approach works by first making a preform of the functional fibres from polycarbonate slabs that are sandwiched together. The outer slabs feature milled grooves running along their entire length to accommodate copper or tungsten wires that interface with the devices in the fibre. In the inner slab, numerous pockets on the order of 100 μm are drilled to accommodate a linear array of semiconductor miniature elements such as p–i–n diodes. The metallic wires are fed through the grooves of the preform and fibres are then fabricated by a thermal drawing process by placing the preform in a three-zone heating furnace, where the top, middle and bottom zones are heated to 150 °C, 270 °C and 110 °C, respectively.

The cross-section of the formed fibre was roughly quadrangular in shape (350 μm × 350 μm). Electrical connection to the in-fibre devices was achieved by stripping away the polycarbonate cladding at one end of the fibre. In principle, the fabrication method enables kilometres of functional fibre to be drawn down from a single preform with more than a hundred discrete devices connected in parallel throughout the entire fibre.

Incorporating these functional fibres into fabrics brings many opportunities for applications. As an example, the US and Swiss scientists demonstrated a textile-based photoplethysmography system for cardiac pulse measurement. A green LED fibre was embedded in a cotton fabric sock adjacent to a GaAs photodetecting fibre. A pulse measurement was implemented by placing an index finger on both fibres. The change of the light intensity recorded by the photodetecting fibre due to the change in the light reflectance from the skin was clearly observed. The measured signal directly correlated with volume changes in small blood vessels, which expanded and constricted with every heartbeat. The functional fibre withstood the strains and stresses of textile manufacturing techniques, and even machine washing. "We envision that this technology will enable new technological advances in the textile and apparel domains, telecommunications, as well as in biological and medical sciences", Rein said. ❐

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Published online: 27 September 2018
https://doi.org/10.1038/s41566-018-0268-3