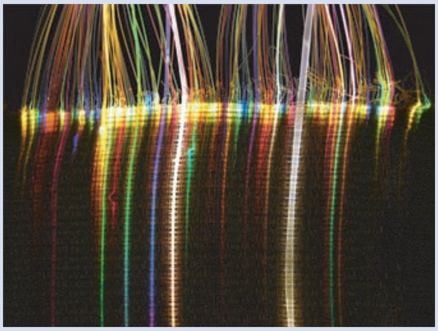
PHOTONIC-BANDGAP FIBRE

Colour-tunable textiles

Since the arrival of optical fibres, low attenuation loss has been the ultimate goal of fibre design for achieving long-distance, lossless optical communication systems. Now it has been shown that all-plastic photonic-bandgap (PBG) fibres, designed to have leaking guided modes, also have great potential for making colour-tunable photonic textiles, thus enriching the functionality of optical fibres (*Opt. Express* **16,** 15677–15693; 2008). These textiles could be useful for producing interactive cloth, sensing fabrics, dynamic signs and art.

So far, all photonic textiles have been made of optical fibres that guide light as a result of total internal reflection. For these fibres, macrobending and surface corrugations are required to extract light from the core, leading to problems, such as uneven luminescence and mechanical defects.

In contrast, the polymer PBG fibres fabricated and used by Bertrand Gauvreau and colleagues from École Polytechnique de Montréal and the National Research Council in Canada, and University of the Arts in the UK, uniformly radiate specific colours of light without the need for dyes, colorants or mechanical perturbation in the core–cladding interface. As a result, they are mechanically robust and resistant to colour fading.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The researchers use Bragg fibres with diameters in the range of 100–600 μm. They consist of a low-refractive-index polymer core surrounded by a periodic sequence of high- and low-refractive-index polymer layers, forming a Bragg reflector. Only light of a particular wavelength is guided along the low-refractive-index core as a result of the PBG of the Bragg reflector. This wavelength can be varied by either changing the refractive index of the core or by using reflector layers of different thicknesses. Owing to the finite number of layers in the Bragg reflector, some of the guided light leaks out of the core. Leaked light is confined in the cladding except at points where imperfections in the cladding–air interface are present, where it is efficiently irradiated. As the colour of the guided modes depend on the fibre geometry rather than the light source, stable emission over time can be achieved.

The researchers show that the fibres appear coloured under ambient illumination, even in the absence of light injected into the core. The colour of light reflected from the fibres can be different from the colour of the leaking guided modes when white light is injected into the core. By controlling the relative intensities of the ambient illumination and the injected light, the overall colour of the fibre as observed in the far field can be varied. In addition, the colour of the guided modes, and thus the overall colour of the fibre, can be varied by changing the thickness of the layers (and therefore the diameter of the fibre), for example, by applying strain. This enables the development of visually interactive textiles, which are responsive to external perturbations and can potentially be used for sensing applications.

Gauvreau *et al.* weaved and evaluated two prototypes of their photonic textiles. They are confident that, with their cost-effective fabrication methods, the colour-tunable photonic textiles based on polymer PBG fibres will offer an economical solution suitable for industrial scale-up in textile applications.

Rachel Won

PHOTONIC CRYSTALS

Photons and electrons confined

Researchers have demonstrated the first photonic-crystal system with light emitters that experience three-dimensional photonic and electronic confinement.

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Photonic crystals, specifically three-dimensional (3D) photonic crystals — structures with a periodic modulation of their dielectric constant on the length scale of the wavelength of light in all three dimensions — promise much. However, so far the number of real applications has been rather disappointing. Perhaps a close analogy is GaAs, where there is an old joke that 'GaAs is always the technology of the future, never the technology of the present'. Yet, the outstanding potential of 3D photonic crystals for zero-threshold lasers[1], on-chip 3D waveguides[2,3], unique planar optical elements[3], superprisms[4], and more, has kept the field vibrant and active. It is exciting to now see that the photonic-crystal technology of the future is becoming the technology of the present. On page 688 of this issue, Aoki *et al.* demonstrate the first 3D photonic crystal containing completely confined electrons and photons, using a structure formed by layer specific placement of quantum dots in a three-dimensional photonic-crystal cavity (Fig. 1)[5]. Fully confined electrons and photons in a single system may enable major technological advances, such as those outlined above.