KEEPING VERY BRIGHT LIGHT BEHIND BARS IN PHOTONIC CRYSTAL FIBRES

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Photonic crystal fibres (PCFs) have been the focus of increasing scientific and technological interest since the first working example was reported in 1996 [1-3]. Although superficially similar to a conventional optical fibre, PCF has a unique microstructure, consisting of an array of microscopic holes (i.e., channels) running along its entire length. These holes act as optical barriers or scatterers, which suitably arranged can "corral" light within a central core (either hollow or made of solid glass). The holes can range in diameter from ~25 nm to ~50 μm. Although most PCF is formed in pure silica glass, it has also recently been made using polymers [4] and other compound silica and tellurite glasses [5,6], where it is difficult to find compatible core and cladding materials.

PCF supports two guidance mechanisms: total internal reflection, in which case the core must have a higher average refractive index than the holey cladding; and a two-dimensional photonic bandgap, when the index of the core is uncritical – it can be hollow or filled with material [2]. Light can be controlled and transformed in these fibres with unprecedented freedom, allowing for example the guiding of light in a hollow core, the creation of highly nonlinear solid cores with anomalous dispersion in the visible and the design of fibres that support only one transverse spatial mode at all wavelengths.

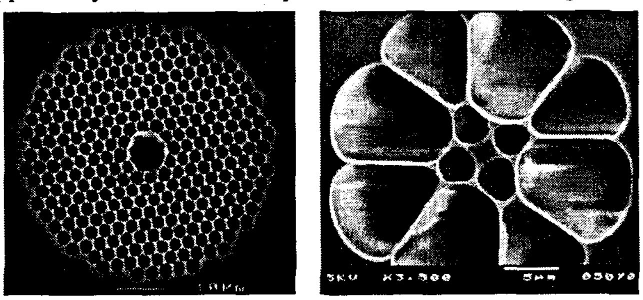

Figure: (a) state-of-the-art hollow core PCF. (b) Extruded SF6 glass fibre for producing a super-continuum out to 2300 nm [5]

For example, an ultra-small core fibre made from solid glass and surrounded by very large air-holes can be arranged to have a zero chromatic dispersion wavelength in the 800 nm Ti:sapphire band [7]. This fibre produces spectacular spectral broadening of high repetition rate 100 fsec pulses, with a brightness some 10,000□ brighter than the sun and a similar bandwidth. This source is transforming the fields of optical coherence tomography, spectroscopy and frequency metrology [8]. The ability to control dispersion over broad bands of wavelengths is ushering in a new era in nonlinear optics [9,10]. Recently a supercontinuum spectrum extending out to 2300 nm has been demonstrated in a SF6 glass PCF using a 1550 nm fsec pump laser (see Figure).

In its hollow core form [11], PCF also solves a key long-standing challenge in photonics, for which there is no good conventional solution: How to force light to interact – strongly, reproducibly and over long path-lengths – with low-density materials such as gases, vapours and liquids. This is an exciting development with major implications for numerous gas-based nonlinear optical and laser devices. Recently a hydrogen Raman cell was demonstrated [11] with a threshold energy of 800 nJ – some 100□

lower than previously reported. In March 2004, breakthrough losses of 1.7 dB/km were reported in hollow-core photonic bandgap fibre [13], and MW soliton propagation explored [12]. Fully characterised hollow core PCF is now commercially available with losses below 0.1 dB/m [15].

These examples illustrate how the PCF concept is ushering in a new and more versatile era of fibre optics, with a multitude of different applications spanning many areas of science.

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